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National Aeronautics and
Space Administration

Budget Estimates

Fiscal Year 1994

Volume I
Agency Summary

Research and Development

Space Flight, Control and Data Communications

(NASA-TM-110815) BUDGET ESTIMATES: FISCAL YEAR 1994. VOLUME 1: AGENCY SUMMARY (NASA) 357 p

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

VOLUME 1

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 BUDGET ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration (NASA) leads the United States' preeminent programs in aeronautics, space exploration, and flight activities for peaceful purposes. Its unique mission of exploration, discovery, and innovation has preserved the United States as both the leader in world aviation and as the preeminent spacefaring nation.

The NASA FY 1994 budget request of $15,265 million demonstrates the President's strong commitment to space and aeronautics. This budget concentrates on:

- Investing in the development of new technologies including a particularly aggressive program in aeronautical technology; to improve the competitive position of the United States, through shared involvement with industry and other government agencies;

- Continuing the nation's premier program of space exploration, to expand our knowledge of the solar system and the universe as well as the Earth, in an effort to understand the nature of global environmental problems; and

- Providing safe and assured access to space using both the Space Shuttle and Expendable Launch Vehicles.

This budget request strengthens the leadership position of NASA as an innovator and the future competitiveness of the United States by investing in the scientific and engineering community. NASA has undertaken a far reaching evaluation of all its activities to search for new ways of doing business and to find significant savings. Special teams conducted intense reviews of all the Agency's programs, and the results of these reviews have been incorporated into the NASA program. In addition, the President has directed NASA to undertake an intense effort to redesign the Space Station. Funding for the Space Station, activities which support utilization of the Space Station, and other initiatives to stimulate the development of new technology is included in the Space Station and New Technology Investments package. Details of these activities will be provided in June as part of the redesigned Space Station package.

Space Science and Applications

The Space Science and Applications program is designed to expand our understanding of scientific phenomena, ranging from the intricacies of the universe to the subtleties of the planet Earth. The FY 1994 budget provides for a carefully coordinated and logically phased set of research and development activities to:

- Advance our scientific knowledge of Earth and the global processes which shape our environment:
- Explore the solar system using automated spacecraft in conjunction with ground-based observations and research:
- Expand our comprehension of the universe beyond the solar system using the full range of capabilities from Explorer spacecraft to the "Great Observatories":
- Increase our knowledge in the life sciences on key issues ranging from human performance and habitation in space to the basic life processes and the potential of life elsewhere in the universe; and
- Understand and develop the potential benefits of the microgravity environment in materials sciences and other applications.

The Space Science and Applications program has been restructured into three new organizational elements. Space Science includes activities related to the exploration of the solar system, our understanding of the origin and evolution of the universe, the fundamental laws of physics, and the formation of the stars and planets. Life and Microgravity Sciences includes activities supporting use of the unique environment of space to increase our understanding of the impact of microgravity on the human body and the behavior of materials. Mission to Planet Earth includes activities which support increasing our understanding of the global environment as an integrated system.

Space Science

Development is continuing on the Advanced X-ray Astrophysics Facility (AXAF) and Cassini missions. The AXAF and Cassini programs have undergone significant revision to accommodate constrained outyear funding availability. The AXAF program now includes two missions. AXAF-I is scheduled for launch on the Space Shuttle in FY 1998, although NASA is actively pursuing procurement of a Titan IV expendable launch vehicle for this mission. AXAF-S is scheduled for launch in CY 1999 on a medium-class expendable launch vehicle. The AXAF-I will focus on high resolution imaging and dispersive spectroscopy, and the AXAF-S will perform high spectral resolution spectroscopy. The Cassini spacecraft has been redesigned to accommodate constrained funding in FY 1993 and a reduced total runout cost, while maintaining the October 1997 launch date and mission science objectives. Funding is also included to continue development of the Global

Geospace Science (GGS) Wind and Polar spacecraft, the ongoing Explorer program and the Gravity Probe-B mission. Funding to provide experiment hardware and research support for a Spacelab visit to the Russian Space Station Mir, scheduled for 1995, is included. This mission will augment ongoing data exchange on experimental results from Mir's long-duration missions. Mission Operations funding will support the Hubble Space Telescope servicing mission, scheduled for December 1993, and previously launched missions, including Mars Observer, Galileo, Ulysses, the Cosmic Background Explorer (COBE), the Extreme Ultraviolet Explorer (EUVE), and the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX). In addition, funding for science data management, archiving and science networking are also provided for under the Space Science program.

Life and Microgravity Sciences

Funding is included for continuing research activities in understanding the response of biological mechanisms and materials science to weightlessness, and the development of experiment hardware for use on the Space Shuttle. In Life Sciences, definition and development of experiments and hardware for Spacelab Life Sciences (SLS) series and other international flight opportunities will continue, including the 1995 Shuttle/Mir rendezvous mission. A main theme in the research conducted in Life Sciences is the use of gravity as an experimental variable to define the responses of biological systems to a micro- or zero-gravity environment. Funding is included to expand cooperation with the National Institute of Health (NIH) in biomedical research programs. Specific research initiatives are under development to expand participation of the mainstream biomedical community in the NASA Life Sciences program. NASA will have the lead in joint space flight research activities; NIH will lead in joint ground-based research activities.

Funding for Microgravity research will continue basic and applied research activities as well as the payload development effort, using Shuttle middeck, Spacelab, and cargo-bay experiments leading to several flights over the next few years, including the International Microgravity Laboratory (IML-2) mission, the U.S. Microgravity Laboratory (USML), and the U.S. Microgravity Payload (USMP) series. Funding to support the mission planning, management, and integration activities are included in this program.

Mission to Planet Earth

NASA is a major participant in the U.S. Global Change Research program. The Earth Observing System (EOS) and Earth Probes are the major NASA contributions to this program, and remain high priorities. Several changes have been made to the EOS program to reduce the program's overall cost, however, no change to the science objectives of the program have been made. Funding for the Earth Probes, which will address specific, highly-focused Earth science investigations requiring unique orbits or special sensor environments, is included. This program includes a Total Ozone Mapping Spectrometer (TOMS) free-flyer scheduled for launch in 1993, a TOMS instrument which will be launched aboard the Japanese ADEOS mission, the Scatterometer scheduled for launch in 1995, and the Tropical Rainfall Mapping Mission (TRMM) scheduled

for launch in 1997. In addition, a TOMS instrument was launched aboard a Soviet spacecraft in 1991. Mission Operations funding is included for the Upper Atmosphere Research Satellite (UARS) data analysis, which initiated the U.S. Global Change program. Funding is also included for continued development of Landsat-7, which is being managed by a joint NASA/DOD team. The data provided by Landsat-7 will be an integral part of the U.S. Global Change program. An active basic research program is also maintained.

Space Transportation

The Space Transportation program continues safe operation of the fleet of Space Shuttles, accomplishing seven flights during FY 1992. The Space Shuttle Endeavour flew its maiden voyage in May 1992, during which the Intelsat satellite was retrieved and repaired, and three new spacewalk records were set. Other missions accomplished during 1992 included two highly successful Spacelab missions focusing on Material Science, the first dedicated Astrophysics Laboratory (ATLAS-1) flight, launch of a DOD satellite, and the initial flight of the U.S. Italian Tether Satellite system.

The Shuttle program has undergone an intense review to reduce costs without sacrificing safety. Management operations efficiencies and program changes have been incorporated which result in significant savings. Funding for the highest priority Safety and Obsolescence Upgrade activities is included, as is funding for high risk Structural Spares items. Funding for the continued development of the Advanced Solid Rocket Motor is included. The budget provides for conducting eight missions per year as a baseline flight rate. Funding is included to purchase a docking mechanism from the Russians and make the necessary modifications to the Shuttle to support the planned rendezvous and docking with the Russian Space Station Mir and to support missions of up to 30 days.

Aeronautics Research and Technology

Aviation in general, and the aeronautics industry in particular, play a major role in supporting the economic strength, transportation infrastructure and national defense capabilities required for the long-term well being of the United States. Increased investment in aeronautics research, technology and facilities, as well as high-performance computing capabilities, is an important element in the President's plan to revitalize technology development to strengthen America's competitive position. The goal of the Aeronautics program is to conduct aeronautical research and develop technology to strengthen the U.S. leadership in civil and military aviation. This is accomplished by maintaining a broad-based research and technology program utilizing advanced facilities, laboratories, computers and technical staff, with extensive involvement of the U.S. university and industrial sectors.

This budget request maintains a strong commitment to develop a broad technology base in support of the aviation industry, enhance safety and capacity of the national airspace system, and assure U.S. superiority for national defense. Funded is including to augment the High Speed Civil Transport (HSCT) program by conducting research to develop the advanced propulsion, materials, aerodynamics, and flight deck

technologies that are required to assure future environmental compatibility, as well as economic viability. Funding is included for the Advanced Subsonic Technology program. This program will conduct advanced technology for aircraft noise reduction and major aviation system capacity increases through improvements in terminal area productivity. This program will take advantage of industry and Federal Aviation Administration (FAA) cooperation to accelerate applications of these advanced technologies to U.S. aircraft and engine manufacturers and to implement them in the National Aviation System. NASA will also continue as a full and active participant in the multiagency High-Performance Computing and Communications (HPCC) program. NASA's activities are focused on enabling broad advances in aerospace vehicle design, space and Earth systems science. This approach leverages current NASA leadership, while strengthening the capability for sustained high-performance computing research.

Transatmospheric Research and Technology

Funding is included to continue the Transatmospheric Research and Technology program. NASA's contribution to the National Aero-Space Plane (NASP) program. The program continues to make significant advances in the technology base. The technology base includes propulsion, materials and structures, control, and applications of computational fluid dynamics. High-risk program elements (primarily aeropropulsion) and hypersonic flight tests of critical technology elements are the near-term focus.

Advanced Concepts and Technology

A new organization, the Office of Advanced Concepts and Technology (OACT), was established in the fall of 1992 to improve the way in which NASA approaches the development and transfer of advanced technology, as well as the commercialization of space and space technologies. The process of integrating the activities of the Space Research and Technology program and the activities of the Office of Commercial Programs, will be completed in FY 1993.

The Space Research and Technology program develops the technology base on which our current and future capabilities in space depend. The Research and Technology program is responsive to the strong and continuing consensus that investments in advanced research and technology are essential to our future success in space. The program consists of two complementary parts: the Research and Technology (R&T) Base and the Civil Space Technology Initiative (CSTI). The R&T Base serves as the seedbed for new and innovative technologies and capability enhancement. The CSTI will continue to provide specifically for the development of selected technologies at larger scale or higher levels of maturity and, as required, in the relevant environment of space. This will facilitate a more effective technology transfer to the user programs, will reduce missions costs and increase safety and reliability.

NASA continues its commitment to encourage a healthy and expansive commercial space industry through the Technology Transfer and Commercial Use of Space programs. The FY 1994 budget request includes funding in support of the Centers for the Commercial Development of Space (CCDS) and to support the flight tests required by CCDS hardware development activities. The Commercial Middeck Augmentation Module (CMAM) will make its initial flight in FY 1993, providing expanded access to the space environment for experiments developed by the CCDSs. Initial flight of the COMmercial Experiment Transporter (COMET) is also planned for FY 1993.

NASA also seeks to involve the commercial sector in developing the infrastructure for research and working in space. Through the Technology Transfer program, we enhance and accelerate the application and use of aeronautics and space technology by the public, private and academic sectors.

Space and Ground Networks, Communications and Data Systems

The FY 1994 budget provides the vital spacecraft tracking, communications, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. The Second Tracking and Data Relay Satellite System (TDRSS) Ground Terminal (STGT) will be operational in FY 1994 and work on the upgrade of the current White Sands Ground Terminal will continue. Launch of the Replacement TDRS (TDRS-7) is planned for 1995 on the Space Shuttle. Funding is included to procure replenishment TDRS spacecraft that are functionally equivalent to the current spacecraft.

Academic Programs

Science and mathematics achievement is an integral element of the National Education Goals, and NASA's Academic program strongly support making U.S. students first in the world in science and mathematics achievement by the year 2000. NASA's programs at the pre-college, college, and graduate levels are designed to capture and channel student interest in science, engineering, mathematics and technology as well as enhance teacher knowledge and skills related to these subjects. NASA is particularly committed to expanding the opportunities for women and underrepresented minorities in engineering, science and technologies. NASA is seeking to expand the future pipeline of workers to reflect the cultural diversity of the United States, by providing support, through research opportunities and fellowships, to students of underrepresented populations who are pursuing degrees in engineering and science. Funding is provided to Historically Black Colleges and Universities and other Minority Universities to allow them to build their research infrastructure and institutional capabilities. The programs which comprise the NASA education effort are supportive of national educational reform movements which are seeking to strengthen learning, teaching and assessment standards.

Institutional Capability

The NASA institutional capability is the fundamental underpinning for successful accomplishments of the Nation's Aeronautics and Space program. This capability is comprised of the people who plan, conduct and oversee the research, development and test activities of NASA, as well as the valuable and unique NASA facilities. The FY 1994 request provides for the necessary facility development and maintenance to support the NASA program and to support a Full-Time Equivalent (FTE) manpower level of 23,623.

The NASA facilities are unique national resources and are the key to maintaining our Nation's leadership position. The maintenance and modernization of these facilities is a high priority to protect the huge investment the Nation has made in them. The Aeronautical facilities are used not only by NASA but are also depended on heavily by the DOD and the U.S. industry, and are key to making the industry more competitive. A significant new initiative is included to expand the National Aeronautics Facilities Upgrade program begun in FY 1993 to improve the capability of these aeronautics facilities. Funding is also included to support facilities requirements for the EOS, Space Communications, and Space Flight programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FY 1994 BUDGET SUMMARY
(Millions of Dollars)

		Budget Plan	
	1992	1993	1994
RESEARCH AND DEVELOPMENT	6,827.6	7,089.3	7,712.3
Space station & new technology investments	2,002.8	2,122.5	2,300.0
Space transportation capability development	739.7	649.2	649.2
Physics and astronomy	1,036.7	1,103.8	1,074.7
Planetary exploration	534.2	473.7	557.2
Life sciences	157.6	140.5	
Life & microgravity sciences & applications			351.0
Space applications	985.1	1,148.0	
Mission to planet Earth			1,074.9
Space research and technology	309.2	272.7	298.2
Commercial programs	147.6	164.4	172.0
Aeronautical research and technology	788.2	865.6	1,020.7
Transatmospheric research and technology	4.1	--	80.0
Safety, reliability and quality assurance	33.6	32.7	35.3
Academic programs	66.8	92.9	74.5
Tracking and data advanced systems	22.0	23.3	24.6
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	5,384.8	5,086.0	5,316.9
Shuttle production and operational capability	1,296.4	1,053.0	1,189.6
Shuttle operations	3,029.3	3,016.0	3,006.5
Launch services	155.8	180.8	300.3
Space and ground networks, communications & data systems	903.3	836.2	820.5
CONSTRUCTION OF FACILITIES	531.4	525.0	545.3
RESEARCH AND PROGRAM MANAGEMENT	1,575.8	1,615.0	1,675.0
INSPECTOR GENERAL	13.9	15.1	15.5
TOTAL BUDGET AUTHORITY	14,333.5	14,330.4	15,265.0
OUTLAYS	13,959.9	14,077.6	14,670.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS

(Millions of Dollars)

	TOTAL	R & D	SFC&DC	CofF	R&PM	IG
Fiscal Year 1992						
Appropriation P.L. 102-139	14,352,775	6,413,800	5,157,075	525,000	2,242,300	14,600
Appropriation Transfer P.L. 102-139	--	438,556	227,700	--	-666,256	--
Recission Pursuant to P.L. 102-298	-4,050	-4,050	--	--	--	--
Recission Pursuant to P.L. 102-389	-14,300	-14,300	--	--	--	--
Transfer Between Accounts	--	-6,400	--	6,400	--	--
Lapse of FY 1992 Unobligated Funds	-911	--	--	--	-188	-723
Total Budget Plan	14,333,514	6,827,606	5,384,775	531,400	1,575,856	13,877
Fiscal Year 1993						
Appropriation P.L. 102-389/Budget Plan	14,330,376	7,089,300	5,086,000	525,000	1,615,014	15,062
Proposed Supplemental	(4,696)	(4,696)	--	--	--	--
Total Budget Plan	14,330,376	7,089,300	5,086,000	525,000	1,615,014	15,062
Fiscal Year 1994						
Appropriation Request/Budget Plan	15,265,000	7,712,300	5,316,900	545,300	1,675,000	15,500

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION

(Thousands of Dollars)

	Total			Space Flight Control and Data Communications			Research and Development			Construction of Facilities			Research and Program Management		
	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994
Johnson Space Center	2,977,315	2,876,649	1,999,946	1,279,921	1,248,300	1,311,500	1,419,927	1,360,058	399,375	31,523	15,816	27,985	245,944	252,475	261,086
Kennedy Space Center	1,567,295	1,554,223	1,514,424	1,081,700	1,088,400	1,077,200	269,053	267,752	212,237	61,078	35,032	56,430	155,464	163,039	168,557
Marshall Space Flight Center .	3,144,023	2,988,362	2,700,410	1,893,400	1,678,301	1,839,120	962,507	1,005,716	580,633	56,459	69,615	37,810	231,657	234,730	242,847
Stennis Space Center..........	96,319	83,040	92,232	41,200	37,600	41,900	24,069	17,157	18,563	16,786	13,640	16,490	14,264	14,643	15,279
Goddard Space Flight Center ..	2,117,153	2,159,455	2,248,050	665,723	610,121	610,180	1,156,939	1,257,313	1,325,679	44,502	34,175	45,880	249,989	257,846	266,311
Jet Propulsion Laboratory	860,694	815,689	893,509	177,739	187,400	185,800	670,556	618,219	695,789	12,399	10,070	11,920	0	0	0
Ames Research Center	646,129	685,863	721,921	18,900	22,363	24,000	427,959	437,876	479,342	40,410	62,748	49,050	158,860	162,876	169,529
Langley Research Center	546,385	555,682	644,419	201	0	0	341,978	360,611	435,622	31,355	15,470	22,180	172,851	179,601	186,617
Lewis Research Center	939,399	1,013,649	791,613	64,700	46,500	145,700	679,608	762,995	409,884	22,765	25,820	50,260	172,326	178,334	185,769
Headquarters	1,212,738	1,340,658	1,120,936	161,291	167,015	81,500	875,010	1,001,603	855,176	1,936	570	5,255	174,501	171,470	179,005
Space Station (Under Review)	0	0	2,300,000	0	0	0	0	0	2,300,000	0	0	0	0	0	0
Undistributed Construction of Facilities:															
Various Locations	184,307	218,744	195,040	0	0	0	0	0	0	184,307	218,744	195,040	0	0	0
Facility Planning and Design	27,880	23,300	27,000	0	0	0	0	0	0	27,880	23,300	27,000	0	0	0
Total Budget Plan	14,319,637	14,315,314	15,249,500	5,384,775	5,086,000	5,316,900	6,827,606	7,089,300	7,712,300	531,400	525,000	545,300	1,575,856	1,615,014	1,675,000
Inspector General............	13,877	15,062	15,500	---	---	---	---	---	---	---	---	---	---	---	---
Total Agency..................	14,333,514	14,330,376	15,265,000												

DISTRIBUTION OF FULL TIME EQUIVALENT WORKYEARS BY INSTALLATION

	1992	1993		1994
	ACTUAL	BUDGET ESTIMATE	CURRENT ESTIMATE	BUDGET ESTIMATE
JOHNSON SPACE CENTER	3,640	3,631	3,606	3,548
KENNEDY SPACE CENTER	2,543	2,510	2,508	2,467
MARSHALL SPACE FLIGHT CENTER	3,735	3,650	3,660	3,560
STENNIS SPACE CENTER	221	216	213	211
GODDARD SPACE FLIGHT CENTER	3,988	3,985	3,954	3,894
AMES RESEARCH CENTER	2,256	2,225	2,211	2,185
LANGLEY RESEARCH CENTER	2,946	2,925	2,914	2,869
LEWIS RESEARCH CENTER	2,799	2,787	2,757	2,725
HEADQUARTERS	1,932	2,006	1,934	1,924
SUBTOTAL, FULL–TIME PERMAMENT WORKYEARS	24,060	23,935	23,757	23,383
OTHER THAN FULL–TIME PERMAMENT WORKYEARS	270	296	232	240
SUBTOTAL, CEILING CONTROLLED FTE	24,330	24,231	23,989	23,623
CORE		500	0	0
GRAND TOTAL, CEILING CONTROLLED FTE	24,330	24,731	23,989	23,623

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

The FY 1994 multi-year budget estimate is submitted in accordance with the NASA FY 1989 Authorization Law (P.L. 100-685). The enclosed table contains the budget estimates for FY 1994, along with the Administration's projections for 1995 and 1996. The President has directed NASA to undertake an intense effort to redesign the Space Station. Funding for the Space Station, activities which support utilization of the Space Station, and other initiatives to stimulate the development of new technology is included in the Space Station and New Technology Investments package. Details of these activities will be provided in June as part of the redesigned Space Station package.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FY 1994 MULTI-YEAR BUDGET ESTIMATES
IN MILLIONS OF REAL YEAR DOLLARS

FY 1994 PRESIDENT'S BUDGET	1992 PAST YEAR	1993 CURRENT YEAR	1994 BUDGET YEAR	1995 ESTIMATE	1996 ESTIMATE
RESEARCH & DEVELOPMENT	6,827.6	7,089.3	7,712.3	8,235.8	8,341.3
SPACE STATION & NEW TECHNOLOGY INVESTMENTS	2,002.8	2,122.5	2,300.0	2,300.0	2,300.0
SPACE TRANSPORTATION CAPABILITY DEV	739.7	649.2	649.2	643.3	639.0
PHYSICS AND ASTRONOMY	1,036.7	1,103.8	1,074.7	1,147.3	1,183.4
PLANETARY EXPLORATION	534.2	473.7	557.2	561.8	492.6
LIFE SCIENCES	157.6	140.5			
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS			351.0	320.7	282.0
SPACE APPLICATIONS	985.1	1,148.0			
MISSION TO PLANET EARTH			1,074.9	1,448.1	1,508.4
SPACE RESEARCH AND TECHNOLOGY	309.2	272.7	298.2	333.1	372.1
COMMERCIAL PROGRAMS	147.6	164.4	172.0	141.4	132.7
AERONAUTICAL RESEARCH AND TECHNOLOGY	788.2	865.6	1,020.7	1,115.0	1,178.8
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	4.1	0.0	80.0	80.0	100.0
SAFETY, RELIABILITY AND QUALITY ASSURANCE	33.6	32.7	35.3	38.5	40.1
ACADEMIC PROGRAMS	66.8	92.9	74.5	81.5	85.6
TRACKING AND DATA ADVANCED SYSTEMS	22.0	23.3	24.6	25.1	26.6
SPACE FLIGHT, CONTROL & DATA COMMUNICATIONS	5,384.8	5,086.0	5,316.9	5,371.0	5,658.2
SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	1,296.4	1,053.0	1,189.6	1,232.3	1,250.6
SHUTTLE OPERATIONS	3,029.3	3,016.0	3,006.5	2,810.4	2,950.9
SPACE & GROUND NETWORKS, COMMUNICATIONS & DATA SYS	903.3	836.2	820.5	1,014.6	1,093.3
LAUNCH SERVICES	155.8	180.8	300.3	313.7	363.4
CONSTRUCTION OF FACILITIES	531.4	525.0	545.3	387.2	375.0
RESEARCH AND PROGRAM MANAGEMENT	1,575.8	1,615.0	1,675.0	1,703.0	1,752.0
INSPECTOR GENERAL	13.9	15.1	15.5	16.0	16.5
TOTAL	14,333.5	14,330.4	15,265.0	15,713.0	16,143.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the technology for practical applications of space technology; to develop and improve manned and unmanned space vehicles; and to assure continued development of the long-term aeronautics and space research and technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE STATION AND NEW TECHNOLOGY INVESTMENTS: A program to provide for a redesigned Space Station, which will provide significant research capabilities in life sciences and materials science, and a series of new technology investments to contribute to U.S. scientific, technological and economic goals. The details of this package will be submitted to the Congress in June.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT: A program to provide for the development and use of capabilities primarily related to the Space Shuttle. The principal areas of activity in Space Transportation Capability Development are efforts associated with the development and operations of the Spacelab system for NASA Shuttle payloads; engineering and technical base support at the manned NASA centers; payload operations and support equipment; support for the planned Mir-Shuttle rendezvous and joint Spacelab mission; and advanced programs study and evaluation efforts.

SPACE SCIENCE: This program conducts a broad spectrum of scientific investigations to advance our knowledge of the sun, the planets, interplanetary and interstellar space, and the stars of our galaxy and the universe.

LIFE AND MICROGRAVITY SCIENCE: A program to identify and develop the technology for the useful applications of space techniques in the area of materials process research and experimentation, and to explore the effect of the zero-gravity environment of space on human physiology.

MISSION TO PLANET EARTH: A program to provide for the use of space systems, supported by ground-based and airborne observations, to acquire information which will assist in the solution of Earth resources and environmental problems.

SPACE RESEARCH AND TECHNOLOGY: A program of advanced research and technology development to ensure the technologies crucial to support current and future capabilities in space are available.

COMMERCIAL USE OF SPACE: A program to encourage increased industry investment and participation in high technology, space-based research and development, through expanded access to the space environment for experiments developed by the private sector, and the dissemination of advances achieved in NASA's research, technology and development program to both the public and private sectors.

AERONAUTICS RESEARCH AND TECHNOLOGY: A program to conduct the fundamental long-term research and to develop the discipline and systems technology required to maintain United States leadership in aeronautics.

SAFETY, RELIABILITY AND QUALITY ASSURANCE: A program to enhance the safety and technical execution of NASA programs.

ACADEMIC PROGRAMS: This program includes activities to support Agencywide university, minority university, and elementary and secondary school programs.

TRACKING AND DATA ADVANCED SYSTEM: This program includes activities to perform studies and provide for the development of systems and techniques leading to improve tracking and data program capabilities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
RESEARCH AND DEVELOPMENT
FISCAL YEAR 1994 ESTIMATES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Millions of Dollars)		
SPACE STATION & NEW TECHNOLOGY INVESTMENTS	2,002.8	2,250.0	2,122.5	2,300.0
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	739.7	863.7	649.2	649.2
PHYSICS AND ASTRONOMY	1,036.7	1,113.5	1,103.8	1,074.7
PLANETARY EXPLORATION	534.2	487.2	473.7	557.2
LIFE SCIENCES	157.6	177.2	140.5	
LIFE & MICROGRAVITY SCIENCES & APPLICATIONS				351.0
SPACE APPLICATIONS	985.1	1,207.1	1,148.0	
MISSION TO PLANET EARTH				1,074.9
SPACE RESEARCH AND TECHNOLOGY	309.2	332.0	272.7	298.2
COMMERCIAL PROGRAMS	147.6	171.6	164.4	172.0
AERONAUTICAL RESEARCH AND TECHNOLOGY	788.2	890.2	865.6	1,020.7
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	4.1	80.0	--	80.0
SPACE EXPLORATION	(3.5)	31.8	--	--
SAFETY, RELIABILITY AND QUALITY ASSURANCE	33.6	32.5	32.7	35.3
ACADEMIC PROGRAMS	66.8	71.4	92.9	74.5
TRACKING AND DATA ADVANCED SYSTEMS	22.0	23.2	23.3	24.6
TOTAL	6,827.6	7,731.4	7,089.3	7,712.3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT

[(INCLUDING RESCISSION OF FUNDS)]

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; purchase, lease, charter, maintenance, and operation of mission and administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration; not to exceed $35,000 for official reception and representation expenses; and purchase (not to exceed thirty-three for replacement only) and hire of passenger motor vehicles; [$7,089,300,000] *$7,638,300,000*, to remain available until September 30, [1994: *Provided*, That $2,100,000,000 shall be made available for implementing the restructured Space Station Freedom program without substantive deviation from the on-orbit assembly sequence outlined by NASA in March 1990, endorsed by the National Space Council, and confirmed by the Committees on Appropriations in House Report 102-226: *Provided further*, That $391,000,000 shall be made available for the development of the Earth Observing System (EOS) and EOS Data Information System (EOSDIS)] *1995*.

[Of the amounts made available under this heading in Public Law 102-139, $14,300,000 for the Climsat mission are rescinded.] *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1993.)*

In addition to amounts otherwise available under this head, and subject to the same terms and conditions, $74,000,000, for subsonic and high-speed research and technology development for short-haul civil aviation aircraft, and for the application of high performance computing and communications to various national needs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

REIMBURSABLE SUMMARY
(In thousands of dollars)

	Budget Plan		
	1992	1993	1994
Space station	2,417	2,833	440
Space transportation capability development	78,615	61,509	63,749
Physics and astronomy	9,170	3,420	5,574
Planetary exploration	405	461	490
Life sciences	825	1,007	
Life and microgravity sciences and applications			785
Space applications	435,733	589,472	
Mission to planet Earth			373,600
Space research and technology	22,324	33,312	34,344
Commercial programs	4,637	3,501	3,600
Aeronautical research and technology	58,600	74,577	76,889
Transatmospheric research and technology	20,050	21,887	22,566
Academic programs	246	602	386
Safety, reliability and quality assurance	647	791	770
Energy technology	19,706	19,890	20,507
Total	653,375	813,262	603,700

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1994 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Station & New Technology Investments	1992	2,002,745	976,469	87,800	424,375	---	75	4,089	1,455	3,609	307,805	197,068
	1993	2,122,467	946,967	101,200	471,300	---	---	2,600	1,000	3,500	364,800	231,100
	1994	2,300,000	UNDER REVIEW									
Space Trans Cap Dev	1992	739,711	282,800	156,400	219,400	16,100	11,800	400	---	1,000	800	51,011
	1993	649,216	239,600	142,300	188,400	9,600	11,600	---	---	1,500	1,100	55,116
	1994	649,200	183,800	178,000	196,300	10,400	8,600	400	---	1,900	1,400	68,400
Physics and Astronomy	1992	1,036,677	14,118	12,231	236,981	---	630,210	36,654	15,788	---	---	90,695
	1993	1,103,860	25,877	13,352	250,148	---	652,481	44,548	23,701	---	---	93,753
	1994	1,074,700	12	---	248,506	---	653,281	51,751	30,578	---	---	90,572
Planetary Exploration	1992	534,221	12,900	---	800	---	11,900	399,521	17,100	650	---	91,350
	1993	473,615	13,700	---	1,000	---	24,575	311,400	10,647	713	---	111,580
	1994	557,200	14,100	---	1,200	---	30,300	367,300	22,400	800	---	121,100
Life Sciences	1992	157,650	63,500	5,700	---	100	300	700	63,050	800	200	23,300
	1993	140,550	59,500	4,900	---	---	200	600	45,850	600	100	28,800
Life & Microgravity Sci	1994	351,000	118,884	24,758	89,360	---	300	10,182	31,700	2,200	36,800	36,816
Space Applications	1992	985,102	2,800	185	49,196	369	461,835	158,550	35,909	30,418	63,619	182,221
	1993	1,148,022	7,700	219	68,164	436	529,711	183,289	42,987	37,904	67,793	209,819
Mission To Planet Earth	1994	1,074,900	---	254	15,672	508	581,384	182,805	38,932	37,707	1,864	215,774

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1994 ESTIMATES
DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Research & Tech	1992	309,172	15,090	2,673	25,202	640	21,845	44,186	31,643	55,066	72,939	39,888
	1993	272,729	6,550	2,380	20,000	270	16,803	49,450	23,906	47,525	64,703	41,142
	1994	298,200	7,700	3,800	23,300	300	23,800	56,700	28,600	50,600	66,300	37,100
Commercial Programs	1992	147,600	44,546	1,120	2,070	5,250	2,752	2,140	1,663	1,283	5,275	81,501
	1993	164,374	54,314	1,030	2,140	4,785	2,673	1,666	1,725	762	4,346	90,933
	1994	172,000	70,065	2,400	2,403	5,835	3,291	2,041	1,345	1,035	3,717	79,868
Technology Transfer	1992	32,500	4,546	320	970	750	1,452	640	763	1,083	775	21,201
	1993	29,495	2,495	380	1,000	785	1,298	675	1,225	527	880	20,230
	1994	26,900	905	560	1,483	635	1,775	925	1,045	996	1,205	17,371
Commercial Use Of Space	1992	115,100	40,000	800	1,100	4,500	1,300	1,500	900	200	4,500	60,300
	1993	134,879	51,819	650	1,140	4,000	1,375	991	500	235	3,466	70,703
	1994	145,100	69,160	1,840	920	5,200	1,516	1,116	300	39	2,512	62,497
Aero Research & Tech	1992	788,192	---	---	---	---	4,100	2,400	259,000	241,000	222,000	59,692
	1993	865,587	---	---	---	---	6,280	2,990	286,317	263,400	254,300	52,300
	1994	1,020,700	---	---	---	---	13,600	3,600	320,000	330,000	289,000	64,500
Transatmos Res & Tech	1992	4,136	---	---	10	---	---	---	901	2,250	893	82
	1993	0	---	---	---	---	---	---	---	---	---	---
	1994	80,000	---	---	---	---	---	---	4,000	7,000	5,000	64,000

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1994 ESTIMATES

DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Safety, Reliability & QA	1992	33,600	3,914	1,818	2,636	620	4,268	5,370	150	2,282	4,232	8,310
	1993	32,707	2,936	1,101	2,059	713	4,591	3,126	221	2,107	3,982	11,871
	1994	35,300	2,140	1,925	1,660	480	2,771	1,390	350	2,066	4,136	18,382
Academic Programs	1992	66,800	3,790	1,126	1,837	990	1,754	1,146	1,300	3,620	1,845	49,392
	1993	92,900	2,914	1,270	2,505	1,353	2,026	2,150	1,522	2,600	1,871	74,689
	1994	74,500	2,674	1,100	2,232	1,040	1,952	2,020	1,437	2,314	1,667	58,064
Tracking & Data	1992	22,000	---	---	---	---	6,100	15,400	---	---	---	500
Advanced Systems	1993	23,273	---	---	---	---	6,373	16,400	---	---	---	500
	1994	24,600	---	---	---	---	6,400	17,600	---	---	---	600
TOTAL BUDGET PLAN	1992	6,827,606	1,419,927	269,053	962,507	24,069	1,156,939	670,556	427,959	341,978	679,608	875,010
	1993	7,089,300	1,360,058	267,752	1,005,716	17,157	1,257,313	618,219	437,876	360,611	762,995	1,001,603
	1994	7,712,300	399,375	212,237	580,633	18,563	1,325,679	695,789	479,342	435,622	409,884	855,176

NOTE: FY 1994 CENTER DISTRIBUTION DOES NOT REFLECT THE SPACE STATION AND NEW TECHNOLOGY INVESTMENTS FUNDING CURRENTLY UNDER REVIEW

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RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICES OF SPACE FLIGHT AND SPACE SYSTEMS DEVELOPMENT — SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Spacelab	99,200	122,600	114,459	139,900	RD 2-3
Upper stages	41,200	(56,500)	(47,700)	(51,100)	RD 2-7
Engineering and technical base (ETB)	210,800	224,200	214,155	203,400	RD 2-8
Payload operations and support equipment	130,100	153,600	131,500	95,400	RD 2-12
Advanced programs	34,700	57,700	32,897	60,700	RD 2-14
New launch system (NLS)	28,000	125,000	10,042	--	RD 2-17
Tethered satellite system (TSS)	16,400	3,400	3,400	--	RD 2-18
Research operations support	179,311	177,200	142,763	149,800	RD 2-19
Total	739,711	863,700	649,216	649,200	

Distribution of Program Amount By Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Johnson Space Center	282,800	302,400	239,600	183,800
Kennedy Space Center	156,400	173,900	142,300	178,000
Marshall Space Flight Center	219,400	298,000	188,400	196,300
Stennis Space Center	16,100	22,900	9,600	10,400
Goddard Space Flight Center	11,800	9,900	11,600	8,600
Jet Propulsion Laboratory	400	400		400
Langley Research Center	1,000	700	1,500	1,900
Lewis Research Center	800	500	1,100	1,400
Headquarters	51,011	55,000	55,116	68,400
Total	739,711	863,700	649,216	649,200

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

OFFICES OF SPACE FLIGHT AND SPACE SYSTEMS DEVELOPMENT

SPACE TRANSPORTATION PROGRAM

OBJECTIVES AND JUSTIFICATION

Space Transportation Capability Development funds a variety of activities which are needed to fully utilize the manned transportation program. Major activities include: (1) The Spacelab program; (2) the maintenance of an Engineering and Technical Base (ETB) at the Kennedy Space Center, the Marshall Space Flight Center, the Johnson Space Center, and the Stennis Space Center to serve as a source of technical expertise and capability to support the various projects; (3) Payload Operations and Support Equipment to provide critical services to NASA payloads; (4) an Advanced Programs activity needed to study, define, and develop technologies for new capabilities in manned transportation; and (5) funding for Research Operations Support (ROS).

Not included in FY 1994 are the Space Shuttle to Space Station mating and integration activities. The scope and funding for these activities will be driven by the Station redesign effort currently underway. A revised program plan consistent with the redesign proposal selected will be submitted to the Congress at a later date.

Beginning in FY 1993, Upper Stage vehicles are included in the Launch Services budget which is managed by the Office of Space Science. Management of the Solid Propulsion Integrity Program (SPIP) was moved from Upper Stages to Advanced Programs and is discussed in that section of this narrative.

BASIS OF FY 1994 FUNDING REQUIREMENT

SPACELAB

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Development	33,200	19,800	8,600	10,100
Operations	66,000	102,800	105,859	129,800
Total	99,200	122,600	114,459	139,900

OBJECTIVES AND STATUS

The Spacelab is a versatile, reusable facility designed for installation in the cargo bay of the orbiter. Spacelab can serve as both an observatory and a laboratory, thus giving scientists the opportunity to conduct a large variety of scientific experiments in the unique environment of space. Ten foreign nations, including nine members of the European Space Agency (ESA), have participated in this joint development program with NASA. ESA designed, developed, produced, and delivered the first Spacelab hardware, and NASA then procured an additional set of hardware from ESA under the terms of a ESA/NASA Memorandum of Understanding and an Intergovernmental Agreement.

There are two basic Spacelab configurations, modules and pallets. However, the hardware can be set up in a number of different combinations depending on the particular application, including using both modules and pallets on the same mission. The modules consist of one or two cylindrical shells enclosed by two end cones. Users may choose either a short module (one cylinder) or a long module (two cylinders) to meet their particular needs. There are no current plans for a short module. Each module contains a core segment housing basic subsystems (power, cooling, computers, data handling, etc) and an experiment segment carrying racks for conducting various experiments. The module is pressurized to allow a "shirt sleeve" working environment. Easy crew access from the Shuttle middeck during flight is provided by a pressurized tunnel. Modules are generally used for life sciences and space processing applications such as the United States Microgravity Laboratory (USML) and Space Life Sciences (SLS) missions.

Spacelab pallets are unpressurized and consist of multiple segments attached individually to the Orbiter, or up to three segments attached rigidly to each other, and to the Orbiter, in a continuous train. If pallets are flown without a module, essential subsystems can be carried in an "igloo" which provides a pressurized

and thermally controlled environment for the subsystem equipment. The igloo is not accessible to the crew inside the Orbiter. Experiments mounted on a pallet can be controlled from the orbiter cabin, from the ground, or from a module, if the payload complement contains a module. NASA has developed two principal versions of the Spacelab Pallet System (SPS). One supports missions requiring the use of the Spacelab computer system and pallet in a mixed cargo configuration like the Atmospheric Laboratory for Applications and Science (ATLAS) missions. The other version, the Enhanced Multiplexer/demultiplexer Pallet (EMP), supports missions such as the Tethered Satellite System (TSS), Lidar In-space Technology Experiment (LITE), and the Space Radar Laboratory (SRL) which do not require the use of the Spacelab computer system.

Spacelab development funding includes additional hardware to maintain the Spacelab carrier system, ground support equipment, hardware modifications, hardware acquisition, system recertification, and modified or improved hardware to expand Spacelab capabilities and ensure its continued operational availability. Support software and procedures development, testing, and training activities not provided by ESA, but which are required for the Spacelab, are also included in NASA's funding request. Additional Spacelab hardware, including spare hardware, is being procured from European and U.S. sources as needed to support the flight manifest.

The Spacelab operations budget includes mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, system operations support, payload operations control support, payload processing, logistical support and sustaining engineering. The Spacelab operations cycle is repeated with each Spacelab flight but with a different payload complement. This cycle consists of three integration steps. Level IV covers the integration and checkout of experiment equipment with individual experiment mounting elements like racks and pallet segments. This activity is normally performed at the Kennedy Space Center (KSC) but is not part of the Spacelab Operations budget. Level II/III integration then combines and integrates all experiment mounting elements like racks, rack sets, and pallet segments, which have the experiment equipment already installed, and checks this out with the Spacelab software. This is done at the KSC and is funded under the Spacelab Operations budget. Level I integration takes the Spacelab and its payload, integrates it with the Shuttle orbiter, and then checks it out. Level I integration is performed by both the Spacelab contractor and the Shuttle Processing Contractor (SPC). The Spacelab budget funds that portion of Level I integration performed by the Spacelab contractor. The balance is funded in the Shuttle Operations budget.

Spacelab operations also funds smaller, tertiary and secondary payloads like Getaway Specials (GAS), Complex Autonomous Payloads (CAP), and Hitchhiker payloads. GAS payloads are research experiments which are flown in standard canisters and can fit either on the sidewall of the cargo bay or go across the bay (GAS bridge). They are the simplest of the small payloads with limited electrical and mechanical interfaces. To date, 87 GAS payloads have been flown and 33 are in preparation. The CAP missions utilize GAS hardware but are more complex because they utilize more services such as pointing and crew operations. Ten CAP missions have been flown and there are 5-10 opportunities per year. The Hitchhiker payloads are the most complex of the smaller payloads and they provide opportunities for larger, more sophisticated experiments. The Hitchhiker

is composed of two carriers depending upon whether it is attached to the sidewall or goes across the bay. During the mission, the Hitchhiker payloads can be controlled using the aft flight deck computer/standard switch panels or on the ground through a Payload Operations Control Center. Five Hitchhikers have been flown and additional flights are planned in FY 1993 and FY 1994 such as the Super-critical Helium On Orbit Transfer (SHOOT) experiment.

Another item funded in Spacelab operations is the Flight Support System (FSS). The FSS consists of three standard cradles with berthing and pointing systems along with avionics. It is used for on-orbit maintenance, repair, and retrieval of spacecraft. The FSS was used on Solar Max and Upper Atmosphere Research Satellite (UARS) and is required for Hubble Space Telescope (HST) repair/revisit missions.

In FY 1992 three Spacelab module missions were successfully completed. These were the International Microgravity Laboratory (IML-1), United States Microgravity Laboratory (USML-1), and the partially reimbursable Japanese Spacelab mission (SL-J). Three additional missions utilized Spacelab and Shuttle carriers in FY 1992: ATLAS-1, TSS-1, and one Hitchhiker which supported a DOD experiment.

In FY 1993, two Spacelab module missions are planned - the Space Life Science Laboratory-2 (SLS-2), and the partially reimbursable German Spacelab D-2 mission (SL-D2). In addition, the United States Microgravity Payload (USMP-1) has already been flown and an igloo/pallet mission, ATLAS-2, will also be flown. Along with these major missions are numerous smaller Shuttle carriers such as Hitchhikers and Getaway Specials.

In order to support a mid-1995 mission to dock with the Russian Space Station Mir, efforts will be initiated in FY 1993 to process a long module to be flown on this mission. The effort will be a scaled down version of a Spacelab Life Sciences flight. This will not only keep costs at a reasonable level and meet the schedule but will also provide early long duration medical data.

In addition to the support of these missions, analytical and physical integration, configuration management, and software development for future flights will be conducted. Procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue throughout FY 1993 and FY 1994 as will operation of the depot maintenance program.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The $8.2 million decrease is the net effect of reducing funding for planned replacements of obsolete hardware and new hardware acquisitions, identifying operational efficiencies and constraining changes to an absolute minimum, offset by required increases to support the Mir mission and the redistribution of ROS funding. Hardware replacement requirements will be continually assessed as manifest changes and operational experience dictate.

BASIS OF FY 1994 ESTIMATE

Beginning in FY 1994, development funds are required to perform the required modifications to Spacelab for Extended Duration Orbiter (EDO) missions of up to 30 days. These modifications, along with those made under the orbiter budget, would be needed to support Space Station in a man-tended mode as well as for operations in the orbiter on a standalone basis. This will provide an extended stay in space and allow a greater return on scientific experiments. These modifications include a high rate multiplexer upgrade and a video analog switch. The high rate multiplexer upgrade is needed to provide redundancy so that the payload data is protected against potential single point failures that might occur during these extended missions. The video switch is another added redundancy so that the video can be maintained. Other changes include modifications to the tunnel between the Space Shuttle and the Spacelab, an additional nitrogen tank, additional stowage, and other minor items. Spacelab development funding in FY 1994 will also continue to fund replacement of obsolete hardware so that current capabilities can be maintained.

FY 1994 operations funds reflect the program requirements to conduct Spacelab missions consistent with the budget manifest. Missions to be flown in FY 1994 include USMP-2, SRL-1, ATLAS-3, the International Microgravity Laboratory (IML-2), and the Lidar In-space Technology Experiment (LITE-I). Two new missions have been added to the Spacelab manifest since the previous budget. They are the Spacelab module mission to the Russian Space Station Mir and the Materials Science Laboratory (MSL-1) scheduled for launch in FY 1995 and FY 1997 respectively.

BASIS OF FY 1994 FUNDING REQUIREMENT

UPPER STAGES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Development				
Procurement and operations	41,200	(56,500)	(47,700)	(51,100)
Total	41,200	(56,500)	(47,700)	(51,100)

Beginning in FY 1993, Upper Stage vehicles are funded within the Launch Services budget under the Office of Space Science. The Solid Propulsion Integrity Program (SPIP) is funded under Advanced Programs beginning in FY 1993.

BASIS OF FY 1994 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research and test support..............	137,100	148,000	156,600	165,400
Data systems and flight support........	18,200	17,300	9,400	--
Operations support.....................	40,000	42,900	32,955	22,500
Launch systems support.................	15,500	16,000	15,200	15,500
Total..........................	210,800	224,200	214,155	203,400

OBJECTIVES AND STATUS

The Engineering and Technical Base (ETB) provides basic engineering and technical capabilities to support the NASA mission assigned to the programs carried out by the manned space flight centers. The centers are: Johnson Space Center (JSC) including White Sands Test Facility (WSTF), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), and the Stennis Space Center (SSC). It provides engineering and technical capabilities that can be utilized by project offices to carry out unique, R&D and analytical tasks. The tasks of any particular project would not justify investment in the facilities and personnel needed to undertake this R&D, but the requirements of a number of projects, combined with NASA's overall goal of enhancing U.S. aerospace technology, support the requirements for this capability. Additional unique requirements beyond the basic ETB functions of Research and Test Support, Operations Support, and Launch Systems Support are funded by the benefiting programs.

Research and Test Support funds the following activities:

- Personnel and materials needed to operate the engineering and science laboratories at JSC and MSFC. These laboratories do a variety of research in disciplines related to space flight, including life sciences, materials, manufacturing technology, propulsion systems, and life support systems. At JSC, this line supports work in altitude and vacuum chambers, materials testing labs, and a variety of other labs and simulators used to test and to gain understanding of how the space environment affects humans and hardware. JSC also funds testing at WSTF's propulsion test stands. At MSFC, the labs' research and test activities focus on propulsion systems materials, production processes, and environments. MSFC is working on applications of materials such as aluminum-lithium to launch vehicles, and has developed new manufacturing processes such as bonded-platelet combustion chambers. MSFC labs are also investigating spacecraft structures and avionics.

- Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA) oversight at JSC, MSFC, and KSC. The funding supports an independent staff at all three centers to review space flight programs and ensure that the Agency's strict SRM&QA requirements are being met. In addition, KSC does analysis on the technical foundations needed to ensure that safety, reliability, and quality are engineered into current and future-space vehicles. This R&D also helps to ensure that NASA's SRM&QA oversight is based on sound techniques and analysis.

- Super Computer (Class VI) operations at JSC and MSFC. These computers support a wide variety of engineering and technical research done in NASA's labs and in other labs associated with the Agency. The Class VI systems are used for modeling in the analysis of space flight environments and dynamics in order to improve our understanding of how getting to and living in space affects humans, other biological forms, materials, propulsion systems, avionics, and structures.

- Operation of MSFC's Technology Test Bed (TTB). The TTB is a highly instrumented platform to assess technology advances in liquid rocket engines. Starting in FY 1994, the TTB will be funded here rather than in the Space Shuttle Main Engine budget because this is a multi-program facility which supports a wide range of liquid rocket engine research. The TTB is used to provide a basic understanding of internal environments in large liquid rocket engines to help develop health monitoring and instrumentation systems to allow safer operation of future engines, and to test new developments in turbomachinery designs and materials.

The Data Systems and Flight Support budget line covers the JSC ADP operations, equipment, and supplies associated with Center's Information System and Network, Central Computer Facility, and the Integrated Software Technology Laboratory (ISTL). As a result of the phase-in of restructuring of the Agency's institutional budgets in FY 1993, part of the data systems and flight support was transferred to Research and Test Support and to benefiting programs within Research and Development.

Operations Support provides funds for maintenance and repair of the specialized equipment in the labs and test stands at MSFC, WSTF, and SSC. Examples of these include propulsion test stands and cryogenic facilities at MSFC and WSTF. Operations Support also funds engineering laboratory capabilities at SSC and the information resources management support at Headquarters.

Launch Systems Support covers scientific, engineering, and technical capabilities at the KSC which are focused on technologies to improve launch and payload processing. For example, the instrumentation and hazardous gas detection lab develops and tests new hazardous material and contaminant detection techniques as well as other improved sensors and instruments to aid in monitoring payload and launch preparations. The fiber optics and communications lab researches enhancements to the data, audio, and video links between KSC facilities. The Launch Equipment Test Facility (LETF) simulates launch events and conditions in order to

test and qualify new launch support equipment. The robotics lab is seeking ways to apply robotics to payload and launch processing. In addition to these R&D efforts, KSC support also provides launch site users with crucial services such as instrument calibration, Non-Destructive Evaluation (NDE), and chemical sampling and analysis.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $10.0 million to ETB in FY 1993 incorporates a general Congressional reduction of $10.0 million. The general reduction will be achieved through operational efficiencies identified by the Centers including the consolidation of ADP and SRM&QA support contracts, improvements to management processes for documenting and tracking contractor performance, and elimination of repetitive operations in all functions. Adjustments were made to reflect a realignment of content to phase-in the Agency's institutional restructure in FY 1993.

BASIS OF FY 1994 BUDGET ESTIMATE

The FY 1994 estimate incorporates the completion of the restructure process in the ETB functions and reduces funding 3 percent below the FY 1993 level. This request will provide minimal support to the ETB infrastructure and will optimize the capabilities in place to support the NASA mission carried out by the Space Flight Centers. The activities previously discussed will be continued.

In Research and Test Support at JSC key facilities like the Electronic Systems Test Laboratory (ESTL) and the Crew Systems Laboratory will be supported. The ESTL will continue to provide a controlled, calibrated radio frequency environment for performing detailed functional performance evaluations of spacecraft communications equipment. The crew systems lab will continue to provide testing for the flight environment pressures for training flight crews in the operation of the extravehicular mobility unit. Funding will continue to enhance the computational capabilities at JSC and MSFC utilizing the Class VI super computers for solving complex main engine three dimensional dynamics modeling and complex structural analysis. Independent SRM&QA oversight is provided at JSC, KSC, and MSFC. ADP hardware and software support for laboratory operations at JSC is funded here. Also in FY 1994, the Technology Test Bed (TTB) program will be funded in this budget line.

FY 1994 operations funding in ETB will continue to provide technical support at MSFC, WSTF, and SSC. At MSFC, examples include photographic mission imaging support to laboratory functions of processing original still negatives and motion picture film and instrumentation services. Additional examples include: documentation repository for reproduction and microphotography operations related to handling engineering drawings and associated documents and specifications; certification of pressure vessels and systems, valve and component refurbishment; design, development, fabrication and installation of custom products such as space hardware shrouds, thermal blankets, wind shields, and clean room wall coverings; chemical analysis of

gases and fluids for tests; and maintenance and repair services for over 30,000 items of RDT&E equipment. At WSTF, the FY 1994 request supports the maintenance and operations of seven propulsion test stands and laboratory operations such as the test chambers and its supporting data acquisition and control systems (DACS). At SSC, laboratory capabilities for calibration, gas and materials processing, non-destructive evaluations, and fluid component processing will be continued. Headquarters information resources management capability is continued in FY 1994.

As a result of the restructuring of Agency's institutional support in 1994, all of data systems and flight support was transferred to Research and Test Support and to the benefiting programs.

The launch systems support at KSC will maintain scientific, engineering, and technical operations. The technical laboratories calibrate test equipment, review instrumentation reliability data, identify new equipment and measurement technologies, and develop software programs to control standalone and automated calibration. These laboratories also perform non-destructive evaluations including radiography inspection, ultrasonic testing, penetrant testing, and other inspection techniques. Engineering laboratories supported include instrumentation and hazardous gas detection, fiber optics and communications, and the expert systems laboratory. All of these laboratories help to fulfill KSC's role as the NASA space vehicle checkout and launch control center.

BASIS OF FY 1994 FUNDING REQUIREMENT

PAYLOAD OPERATIONS AND SUPPORT EQUIPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Payload operations....................	108,000	131,300	109,200	74,800
Payload support equipment.............	22,100	22,300	22,300	20,600
Total...........................	130,100	153,600	131,500	95,400

OBJECTIVES AND STATUS

The objectives of the Payload Operations and Support Equipment budget are to provide payload services which are required beyond the standard Shuttle services for NASA missions, and to provide reusable support equipment for all payload operations. Optional services include items like: (1) retrieval services, analysis for rendezvous, and proximity operations, (2) special thermal analysis, (3) any modifications to ground facilities particularly in the Shuttle Mission Simulator (SMS) above the standard service, (4) extra shifts required in the Shuttle Engineering Simulator (SES) or any other facilities to satisfy the customer requirements, (5) payload related Extravehicular Activity (EVA) above the standard service, (6) special training or use associated with operation of the Remote Manipulator System (RMS), (7) special services between the Payload Operations Control Center (POCC) and the Mission Control Center (MCC), and (8) any special analysis, testing, or other service not normally included in the standard Shuttle service. Also included is the development of an external airlock. This airlock will be a structure that will be used on OV-104 to support docking with the Russian Mir in 1995. While the inside airlock for OV-104 will be retained for this mission, having external airlocks is an operational requirement for Space Station because it frees up space in the crew compartment and thus enhances longer stay-times on-orbit. In addition, it provides increased payload performance by reducing weight. Payload operations also provides for the maintenance and operation of the Payload Processing Facilities (PPFs) at the launch site and payload-unique hardware to interface with the standard Shuttle payload accommodations.

Payload support equipment estimates reflect the development, testing, and delivery of payload accommodation equipment and capabilities common to multiple NASA missions. A major category is the communications equipment necessary for payload data transmission during ground processing and checkout. This includes fiber optic cabling and an upgraded operational intercom system in the industrial area at the KSC to provide increased flexibility and quality of data transmission among the various payload facilities. Orbiter/payload interface hardware for Hitchhiker, cargo bay cabling, modified aft flight deck panels, and associated displays and controls is also included.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Payload operations and support equipment has decreased $22.1 million from the budget estimate. The primary reason is the reassessment of Space Station integration tasks. EMU requirements and orbiter power conversion units are examples of tasks which are being temporarily suspended pending the outcome of the station redesign effort. Partially offsetting this decrease are increases due to the addition of the external airlock.

BASIS OF FY 1994 ESTIMATE

In FY 1994 payload operations funding will continue to support payload services and mission unique integration for scheduled NASA missions. Major NASA missions receiving support in FY 1994 include Atlas-3, Spacehabs 2 and 3, HST Servicing Mission (HST-SM-1), International Extreme-UV Far-UV Hitchhiker (IEH), IML-2, SRL-1, USMP-2, and the Cryogenic Infrared Spectrometer Telescope for Atmosphere (Christa-Spas 01).

The Space Shuttle to Space Station mating and integration activities, which were previously budgeted in FY 1993, are not included in FY 1994. The scope and funding for these activities will be driven by the Station redesign effort currently underway. Once the redesign studies are complete, these requirements will be better defined and presented at a later date.

BASIS FOR FY 1994 FUNDING REQUIREMENT

ADVANCED PROGRAMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced transportation................	14,900	20,300	9,500	18,400
Advanced operations....................	8,200	12,100	5,400	12,400
Advanced space systems.................	11,600	13,300	10,297	18,300
Solid propulsion integrity program (SPIP)......................	(10,100)*	12,000	7,700	11,600
Total...........................	34,700	57,700	32,897	60,700

*Included in Upper Stages prior to FY 1993.

OBJECTIVES AND STATUS

Advanced programs conducts concept feasibility studies, selected systems definitions and preliminary design (Phase B) studies, and undertakes related high leverage advanced development activities. These provide the necessary technical and programmatic data needed to identify evolving space transportation and systems requirements and to evaluate new technical capabilities. Activity is focused in four areas: (1) Advanced Transportation, (2) Advanced Operations, (3) Advanced Space Systems, and (4) the Solid Propulsion Integrity Program (SPIP).

Advanced transportation activities include both concept studies and advanced development. Studies define flight systems concepts and options for human transportation, heavy lift launch vehicles, and advanced upper stages to satisfy near-term and longer range Agency space transportation requirements in sufficient detail to select cost effective pathways and guide technology. Near-term candidate systems under consideration include advanced boosters, personnel launch systems, and cargo transfer and return vehicles. More advanced concepts include fully reusable two-stage and single stage vehicles. The advanced development program focuses on demonstration and application of promising technologies to existing or new flight programs. Two major projects in this area are: the development and testing of electromechanical actuators, and the development of manufacturing techniques for aluminum lithium alloys.

The advanced operations program continues the pursuit of its goal of reducing the cost of ground and mission operations of the Space Shuttle through the introduction of advanced technologies into the operations environment. Estimated cost savings forecasted by the introduction of advanced operations projects into Space Shuttle mission operations in FY 1992 amounts to almost $5.0 million in annual savings through reduced manpower for mission operations computer support, orbiter process scheduling, and Space Shuttle software verification. Other advanced operations projects will significantly reduce the cost of producing replacement thermal protection tiles for the orbiter, training astronauts for the Spacehab missions, and scheduling Space Shuttle mission simulations.

The advanced space systems program includes concept definition and flight experiments in the following areas: system enabling flight demonstrations, orbital debris studies, and tether applications. Flight demonstrations also provide training for young NASA engineers and managers with early hands-on flight hardware experience. Successful flight demonstrations have been accomplished this past year with the Global Positioning System and Fluid Acquisition and Resupply Flight experiments. The orbital debris program is directed at measuring the orbital debris environment, developing debris growth mitigation measures, and enhancing spacecraft protection and survivability. NASA has continued to conduct measurements of the 1-10 cm debris population at Space Station/Space Shuttle altitudes. By the end of 1992, some 1200 hours of debris environment observations have been completed, reducing the uncertainty in that environment from some 300 percent to approximately 57 percent. The two Small Expendable Deployer System (SEDS) flight deployers and instrumented end masses as well as the Plasma/Motor Generator flight hardware will enable the demonstrations of tether initiated deployment as secondary payloads using the Delta II expendable rocket in mid FY 1993.

The Solid Propulsion Integrity Program (SPIP) was established in 1985 to enhance the nation's engineering data base for solid rocket motors in order to improve their success rate. Improved reliability is coming about as a result of developing and validating data bases and engineering tools for motor design, margins and performance analysis, reproducible fabrication and processing, verification, and by improving the culture across the nation's solid rocket motor infrastructure.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The current estimate reflects a net reduction of $24.8 million. This change is composed of a $25.0 million reduction in program content and a $0.2 million transfer due to the redistribution of ROS funds. The content reduction was accommodated by eliminating studies on the New Launch System (NLS), and significantly reducing ongoing activities in the following areas: support of advanced development activities; ground and flight operations studies; reduced SPIP nozzle, bondline and verification testing work; and deferral of several flight experiments.

BASIS OF FY 1994 ESTIMATE

In FY 1994, major program emphasis will continue to be placed on concept definition, system definition, and advanced development activities for advanced space transportation, advanced operations, advanced space systems, and SPIP. The FY 1994 funding request restores some of the program content originally planned in FY 1993 but deferred in order to accommodate the FY 1993 funding level.

Advanced transportation efforts will focus on developing a deeper understanding of concepts based on current technology which could replace or augment the Space Shuttle early next century. These studies will supplement and substantiate the trades and recommendations of the 1993 Access to Space Report. The increase from FY 1993 levels will allow continuation of advanced development efforts on electromechanical actuation, aluminum-lithium manufacturability, and initiation of vehicle health management. These technologies provide promise for direct infusion into current launch vehicles and will be needed to ensure that future vehicles will be operationally efficient, more reliable, cost effective, and provide improved performance margins.

Advanced operations efforts will continue to identify and demonstrate technologies which will improve efficiency, flexibility, and reliability of current and future space transportation systems. The selective application of expert systems, automation, and other technologies to labor-intensive and hazardous operations are included in advanced operations studies. Launch processing systems, mission control applications, flight planning, training, simulation and other environments will be targeted to demonstrate emerging technologies for improving ground and flight operations cost efficiencies. The requested level is significantly higher than current levels in FY 1993 in order to restart many of these advanced development projects that provide a significant return on investment.

Advanced space systems emphasis will be placed on the demonstration of transportation related flight systems. Flight Experiments, such as the Superfluid Helium On-Orbit Transfer (SHOOT) Demonstration and the Dexterous End Effector, will demonstrate enabling technologies in the space environment. Critical tether-related enabling technologies will be demonstrated using the Small Expendable Deployer System during FY 1994. Orbital debris activities will be focused on characterizing changes in the orbital debris environment as a function of time and establishing measures for mitigation of debris growth trends and spacecraft protection techniques. The increase from FY 1993 levels includes increases for orbital debris studies, initiation of a ground-based automated rendezvous and docking advanced development program, and attaining a sufficient level of flight demonstrations.

The SPIP will focus on nozzles, bondlines, verification testing, and on infusing technology engineering results and cultural changes into flight programs. In FY 1994, the program will continue to sustain the NASA/industry team and infrastructure across the U.S. solid motor community with steady advances in engineering data bases, analytical tools for design, fabrication and verification.

Additional Advanced programs activities are being considered for inclusion in the New Technology Investment package to be defined in June.

BASIS OF FY 1994 FUNDING REQUIREMENT

NEW LAUNCH SYSTEM (NLS)

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
New launch system (NLS)................	28,000	125,000	10,042	

OBJECTIVES AND STATUS

The NLS was to be a joint program with the DOD to develop a new family of launch vehicles. The goal of the program was to greatly improve national launch capability with reductions in operating costs and improvements in launch system reliability, responsiveness, and mission performance. Several NLS configurations with a range of capabilities were studied and an evolutionary path would have been maintained to support growth versions and technology improvements. The initial efforts were focused on developing the Space Transportation Main Engine (STME) since this was the common element of all configurations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The current FY 1993 budget reflects a reduction of $115.0 million. This budget reduction terminates the effort on the NLS while retaining options to develop the STME and/or examine alternative engine technologies until national decisions are made regarding launch vehicles and the role NASA would take in engine development.

BASIS OF FY 1994 FUNDING REQUIREMENT

TETHERED SATELLITE SYSTEM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tethered satellite system (TSS)........	16,400	3,400	3,400	

OBJECTIVES AND STATUS

The Tether mission was flown on STS-46 in August 1992. Resources remaining from FY 1992 and FY 1993 will be used to do required post-mission analysis, flight anomaly testing and analysis, post-flight refurbishment, modifications to fix hardware problems, to place the hardware in storage, and to perform a feasibility study on the reflight of the Tether. At this time, no further Tether missions are manifested.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research operations support...........	179,311	177,200	142,763	149,800

OBJECTIVES AND STATUS

Research Operations Support (ROS) funding provides vital support to the civil service workforce and to the physical plant at the centers and at NASA Headquarters. This funding supports the basic core administrative functions such as personnel, payroll, accounting, procurement, and legal counsel. It also supports centerwide services for civil service staff, such as mail, telephones, janitorial services, transportation, medical (other than astronaut), security, and fire protection as well as maintenance of roads, grounds, and all requirements of administrative buildings. Funding to support activities which directly benefit the NASA programs are included in the program budgets.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1992, establishment of the ROS was initially accomplished by transferring funds contained in the Operation of Installation account in the Research and Program Management appropriation to the Research and Development and Space Flight, Control, and Data Communications appropriations. During FY 1993, a more detailed examination of activities supported by ROS funding was conducted by the program offices to identify support directly related to program activities. Funding for activities dedicated to a single program was transferred to the benefiting program. The decrease of $34.4 million reflects the transfer of $20.0 million consistent with a phase-in of restructuring activity and a reduction of $14.4 million consistent with Congressional action that reduced ROS funding.

BASIS OF FY 1994 ESTIMATE

The FY 1994 estimate is based on the completion of restructuring of the ROS budget in FY 1993. In addition, reductions have been implemented which reflect NASA's internal commitment to holding down costs in all areas and NASA's response to the recent executive order mandating reductions in administrative expenses. As such, it reflects the minimum funding to support administrative and facility maintenance requirements at the NASA centers and NASA headquarters. This includes administrative services that support civil service employees, facility maintenance, maintenance of roads, grounds, and requirements of administrative buildings.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1993 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE AND APPLICATIONS

	Budget Plan				
		1993			
	1992 Actual	Budget Estimate	Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Physics and astronomy..................	1,036,677	1,113,500	1,103,860	1,074,700	RD 3-1
Planetary exploration..................	534,221	487,200	473,615	557,200	RD 4-1
Life sciences..........................	157,650	177,200	140,550	--	
Materials processing in space..........	120,800	195,300	172,934		
Life and microgravity sciences.........	--	--	--	351,000	RD 5-1
Earth science..........................	725,393	868,500	863,848	--	
Communications.........................	20,000	4,600	4,986	--	
Information systems....................	35,000	40,700	36,193	--	
Research operations support............	83,909	98,000	70,061	--	
Mission to planet earth................	--	--	--	1,074,900	RD 6-1
Total..........................	2,713,650	2,985,000	2,866,047	3,057,800	

SPACE SCIENCE AND APPLICATIONS PROGRAM RESTRUCTURING

Beginning in FY 1994, the Office of Space Science and Applications program has been reorganized into three separate program offices -- the Office of Space Science, the Office of Life and Microgravity Sciences and Applications, and the Office of Mission to Planet Earth. The following program alignment has been budgeted as part of this reorganization.

Space Science supports the Physics and Astronomy and Planetary Exploration development, basic research and mission operations/data analysis programs as in previous years. It also includes the science data management, archiving and computer networking activities supporting the National Space Science Data Center (NSSDC) and NASA Science Internet, which had previously been budgeted under Space Applications - Information Systems. In addition, the Exobiology research program has also been transferred to Planetary Exploration to more accurately reflect the nature of the research conducted under this program. Shuttle/Spacelab Payload Mission Mangement and Integration, previously budgeted under Physics and Astronomy, has been transferred to Life and Microgravity Sciences and Applications.

Life and Microgravity Sciences and Applications combines NASA's Life Sciences and Materials Processing programs together with their supporting Spacelab management function. Materials Processing, previously funded under Space Applications, has been renamed Microgravity Research, and remains a distinct element within the new structure. The addition of the Shuttle/Spacelab Payload Mission Mangement and Integration, which has been transferred from Physics and Astronomy, serves to consolidate the on-orbit research in these disciplines together with their associated space access infrastructure.

Mission to Planet Earth (MTPE) encompasses most of the activities previously funded under Space Applications. This includes: the Earth Science program; Information Systems functions which support MTPE (the NASA Center for Computational Science (NCCS) at the Goddard Space Flight Center and the supercomputing facility at the Jet Propulsion Laboratory); the Advanced Communications Technology Satellite (ACTS) program; and the Research Operations Support (ROS) program, which supports the basic core administrative functions at NASA's Goddard Space Flight Center and Headquarters. Elements previously included in Space Applications which are transferred into other program elements include the Materials Processing program (to Life and Microgravity Science and Applications), the space science data center activities associated with Information Systems (to Space Science), and the Search and Rescue program, which has been transferred to Commercial Use of Space to better take advantage of technology advancements.

An accompanying budget crosswalk displays the restructured elements.

SPACE SCIENCE & APPLICATIONS
FY 1994 Congressional Budget Crosswalk
(Dollars in Millions)

	TOTALS	Physics & Astronomy	Planetary Exploration	Life Sciences	Space Applications
<u>Old Structure</u>	3,058.9	<u>1,165.9</u>	<u>546.7</u>	<u>154.4</u>	<u>1,191.9</u>
<u>New Structure</u>	3,058.9				
SPACE SCIENCE	<u>1,631.9</u>				
<u>Physics & Astronomy</u>	<u>1,074.7</u>				
Programs that did not change	1,048.2	1,048.2			
Information Systems	26.5				26.5
<u>Planetary Exploration</u>	<u>557.2</u>				
Programs that did not change	430.8		430.8		
Research & Analysis	126.4		115.9	10.5	
LIFE AND MICROGRAVITY SCIENCE AND APPLICATIONS	<u>351.0</u>				
Shuttle/Spacelab Payload Msn. Mgmt. & Int.	117.7	117.7			
Life Sciences Research & Analysis	49.2			49.2	
Life Sciences Flight Experiments	94.7			94.7	
Microgravity Research & Analysis	18.4				18.4
Microgravity Flight Experiments	71.0				71.0
MISSION TO PLANET EARTH	<u>1,074.9</u>				
Programs that did not change	1,074.9				1,074.9
COMMERCIAL USE OF SPACE	<u>1.1</u>				
Search & Rescue	1.1				1.1

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

PHYSICS & ASTRONOMY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Advanced x-ray astrophysics facility development	150,740	174,000	168,337	260,300	RD 3-6
Gravity probe-b development	--	--	1,900	40,000	RD 3-9
Global geospace science	75,300	60,100	72,647	13,300	RD 3-12
Shuttle/spacelab payload mission management and integration	78,000	101,100	94,018	(117,700)	RD 5-17
Payload and instrument development	118,300	78,200	99,340	53,400	RD 3-14
Explorer development	109,100	112,500	115,832	123,300	RD 3-18
Mission operations and data analysis	375,200	440,900	415,385	416,200	RD 3-21
Research and analysis	69,937	81,400	71,558	72,200	RD 3-26
Suborbital program	60,100	65,300	64,843	69,500	RD 3-29
Information systems	--	--	--	26,500	RD 3-32
Total	1,036,677	1,113,500	1,103,860	1,074,700	

Distribution of Program Amount by Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Kennedy Space Center	12,231	17,659	13,352	--
Johnson Space Center	14,118	16,927	25,877	12
Marshall Space Flight Center	236,981	261,577	250,148	248,506
Goddard Space Flight Center	630,210	668,680	652,481	653,281
Jet Propulsion Laboratory	36,654	51,558	44,548	51,751
Ames Research Center	15,788	24,413	23,701	30,578
Headquarters	90,695	72,686	93,753	90,572
Total	1,036,677	1,113,500	1,103,860	1,074,700

OBJECTIVES AND JUSTIFICATION

Two programs are supported by funds provided under Physics and Astronomy: the Astrophysics program, dedicated to the study of the origin of the universe, fundamental laws of physics, and the nature and evolution of galaxies, stars, and planets; and the Space Physics program, dedicated to the study of cosmic ray plasmas, solar plasmas, and the Earth's and other planets' ionospheres and magnetospheres. Each program conducts development, operation, and research activities in their respective science disciplines.

The objectives of the Astrophysics program are to contribute to our understanding of the origin and evolution of the universe by studying astrophysical phenomena. These include large-scale structures such as galaxies, galactic clusters, and interstellar medium; and stellar objects such as quasars, neutron stars, pulsars, and black holes. Study of these phenomena contributes to knowledge about the formation of astrophysical objects and systems, as well as about the fundamental laws of physics. In addition to its astronomy missions, the Astrophysics program also supports a limited number of initiatives related to relativity science.

Astronomical observation from space allows observations to be conducted without being obscured or distorted by the atmosphere. Many infrared wavelengths are obscured and some wavelengths, such as x-ray and ultraviolet, cannot be observed from the surface of the Earth at all. Resolution of visible wavelengths is also improved when observed from space.

The objectives of the Astrophysics program are accomplished using a mixture of large multi-instrument observatories, medium- to small-sized Explorer spacecraft, instruments and payloads to be flown on international and U.S.-sponsored satellites and Shuttle/Spacelab flights, and airborne astronomy missions. Recently launched and currently operated spacecraft of the Astrophysics program include the Cosmic Background Explorer (COBE, 1989), the Hubble Space Telescope (HST, 1990), the Compton Gamma Ray Observatory (CGRO, 1991), and the Extreme Ultraviolet Explorer (EUVE, 1992). Recent Spacelab missions include the Astro-1 (1990), an astrophysics portion of the Atmospheric Laboratory for Applications and Science (ATLAS-1, 1992), and the Diffuse X-ray Spectrometer (DXS, 1993). NASA also supported the deployment and operation of the international Roentgen Satellite (ROSAT, 1990).

The attention of NASA's Space Physics program is upon naturally-occurring plasmas, the physical state of 99 percent of the universe. Relatively cool plasmas in the planetary ionospheres, the hot plasma of the sun, Earth's and other planets' magnetospheres, and galactic cosmic-ray plasma are all the focus of study supported by the Space Physics program.

Flight programs of the Space Physics program are concentrated on the sun, the heliosphere of naturally occurring plasmas which it generates, and its impact on and relationship to the magnetic, electrical, and atmospheric systems of the Earth. Study of Earth's nearby space environment has revealed a dynamic and complex system of plasmas interacting with the magnetic fields and electric currents surrounding our planet. This region, comprising the magnetized solar-wind plasma plus the perturbation in the heliosphere caused by the presence of the magnetic Earth, is the region defined as the geospace.

Medium-size satellites, Explorer spacecraft, instruments flown on international satellites, balloons, and brief sounding rocket experiments are used to observe and to provide in-situ measures of the geospace. In addition, operation of the Ulysses satellite, and other planetary missions which have exited the solar system, is performed under this program's sponsorship. Studies performed by this program provide crucial details across a range of astronomical, Earth, and basic science disciplines.

Space Physics missions undertaken recently include the Combined Release and Radiation Effects Satellite (CRRES, 1990), the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX, 1992), space physics instruments on the ATLAS-1, 1992 Spacelab mission, and the international Solar-A/Yohkoh (1991) and Geotail missions (1992).

The Astrophysics program is currently developing the Advanced X-ray Astrophysics Facility (AXAF), the Gravity Probe-B (GP-B) relativity experiment, the X-ray Timing Explorer (XTE), the Fast Auroral Snapshot Explorer (FAST), and the Submillimeter Wave Astronomy Satellite (SWAS). The medium-sized Advanced Composition Explorer (ACE), previously funded under Other Explorers, will transition into development in FY 1994.

The AXAF, approved by Congress in FY 1989 as a demonstration of mirror fabrication and testing, has proceeded with science instrument development, continued fabrication and test of its large grazing incidence mirrors, and early design of spacecraft, telescope, and mirror assemblies. Following a restructuring of this system in 1992, AXAF is now composed of two satellites to be launched in 1998 and 1999. Together, the two satellites will provide high resolution imaging and both wide-band and narrow-band coverage of the x-ray spectrum, necessary for both cataloging study and specific investigation of the composition and nature of galaxies, stellar objects, and interstellar phenomena, and the study of basic issues in theoretical physics.

The GP-B is a unique test of Einstein's general theory of relativity. After a lengthy period of science definition, technology demonstration, and design and test of prototypical components, GP-B has been judged to be ready to begin development for flight. Ongoing development of the Shuttle Test of Relavity Experiment (STORE), an in-flight demonstration of GP-B instrument performance funded under Payload and Instrument Development, will continue to support the GP-B satellite development program.

The XTE, SWAS, FAST, and ACE are all funded under the Explorer program. NASA selects Explorer missions to conduct investigations of an exploratory or survey nature, or to achieve specific objectives which do not require the capabilities of a large spacecraft or observatory. The SWAS and FAST are classified as Small Explorers (SMEX).

Ongoing development of systems needed for modification and repair of the Hubble Space Telescope is also supported under the Physics and Astronomy program. A modified science instrument, corrective optics for three other instruments, two new solar arrays, and other subsystems are in development for the December 1993 servicing mission. Other development work related to future servicing missions and to ongoing improvement of ground systems is also supported.

Currently, the HST can resolve spatial features by a factor of ten better than ground-based optical telescopes, or objects as dim as the 24th magnitude. Full capability to observe objects from the 25th to the 28th magnitude, originally planned for Hubble, will be restored by the 1993 servicing mission with the Wide Field/Planetary Camera II (WF/PC II) instrument and the Corrective Optics Space Telescope Axial Replacement (COSTAR) system. This increased capability will allow extended use of the Faint Object Camera (FOC) and Faint Object Spectrograph (FOS) and improved use of the Goddard High Resolution Spectrometer (GHRS). Future enhancements of HST will extend the system's coverage into the infrared and greatly enhance the spectral resolution, efficiency, and sensitivity of HST's ultraviolet coverage. These improvements will allow astronomers to address basic questions concerning the origin, evolution, and disposition of galaxies, quasars, clusters, and stars, allowing us to increase significantly our understanding of both the early and present universe.

The Space Physics program is currently developing two satellites under the Global Geospace Science (GGS) program and several instruments and spacecraft subsystems under the Collaborative Solar Terrestrial Research (COSTR) program. COSTR instruments and subsystems will be used on several international satellites. These two NASA programs represent the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program, a broad initiative to conduct advanced observations and study of the sun and Earth's geospace. Under this program, satellites are being developed by NASA and the European Space Agency (ESA), plus one satellite already produced by the Japanese Institute of Space and Aeronautical Science (ISAS).

NASA's two GGS spacecraft, Wind and Polar, together with Japan's Geotail which was launched in 1992 and other Earth observing and near-Earth satellites, will make the first coordinated geospace measurements of

the interaction between the Earth's magnetic field and plasma from the sun, and the transfer of mass, energy, and heat to the Earth system. Wind will study this transfer at the head of the geospace, Polar at Earth's poles, and Geotail at a point where the Earth's magnetic region tails away.

NASA's COSTR program will provide instruments and subsystems for the European Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft, in addition to the support already provided for the Japanese Geotail spacecraft launched in 1992. SOHO will measure the interior dynamics, magnetic field structure, and output of the sun. Cluster will conduct special 3-dimensional studies of isolated regions within the solar wind and geospace to provide an in-situ metric of plasma flow. Together, the ISTP program will provide a comprehensive understanding of the sun-Earth interaction and its coupling to Earth's climate.

The Astrophysics and Space Physics programs also support the development of a number of instruments and payloads to be used on international satellites or on Spacelab missions. Launch services, scientific guidance, and ground operations support are sometimes linked to NASA's contribution to these programs.

During the past several years, suborbital observation from balloons, sounding rockets, and high-flying aircraft took on increased significance. This enhanced effort will continue to provide observations and instrument development opportunities for research groups. Furthermore, increased emphasis will also continue in the research and analysis (R&A) and the mission operations and data analysis (MO&DA) areas in order to maintain a vital research base.

Both the Astrophysics and Space Physics programs rest on a solid basis of supporting research and new technology development, research, and theory-building. Research teams at NASA centers and at universities, industrial laboratories, and other government laboratories are supported. The scientific information obtained and the technology developed in this program are made available to the scientific communities and the general public for application to the advancement of scientific knowledge, education and technology.

Shuttle/Spacelab mission management and integration of Spacelab payloads to be flown aboard the Shuttle, which also has been supported under NASA's Physics and Astronomy program, will be transferred beginning in FY 1994 to the Life and Microgravity Sciences and Applications program.

BASIS OF FY 1994 FUNDING REQUIREMENT

ADVANCED X-RAY ASTROPHYSICS FACILITY DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
AXAF spacecraft	136,940	148,000	147,337	218,000
Instruments	13,800	26,000	21,000	42,300
Total	150,740	174,000	168,337	260,300
Mission operations and data analysis	(3,300)	(14,900)	(14,900)	(11,600)
Upper stages		(8,000)	(8,000)	(16,100)

OBJECTIVES AND STATUS

The Advanced X-ray Astrophysics Facility (AXAF) will provide new observations and insights into studies of the age and evolution of the universe and its objects: the composition of the universe and its galactic and extra-galactic objects and systems; and fundamental laws of particle physics, plasma physics, and theoretical physics. X-rays, which are invisible from the Earth's surface, are produced in settings where temperatures reach millions of degrees, where particles are accelerated by gravity to nearly the speed of light, and where magnetic fields are more than a trillion times that of the Earth. X-rays are emitted as the result of highly energetic cosmic events, including stellar and galactic explosions, accretion of matter onto compact objects (such as neutron stars and black holes), and in the presence of high temperature gases. These are conditions under which the fundamental nature and relationship of energy and matter can be examined.

AXAF will allow scientists to study quasars, the most distant, luminous, and powerful objects in the universe. AXAF, a follow-on to NASA's High Energy Astronomy Observatory (HEAO-2), the Einstein Observatory, which operated from 1978 to 1981, will allow both deeper and broader search for these objects.

AXAF will also examine the hot remnants of supernovas, explosive ends of stars' lives which will have been unobservable in other galaxies prior to AXAF; contribute to the calculation of the mass of the universe (since x-ray emission of interstellar medium and stellar phenomena is not correlated with visible emission); and study the mysterious phenomena of the x-ray burster and the diffuse x-ray background observed in the universe.

Finally, combining measurements of AXAF and of the microwave irradiance of galactic clusters will yield a 10-fold increase in the precision of the Hubble constant. This constant is the mathematical factor used to relate the observed distance of objects from the Earth to the speed at which the universe is expanding.

AXAF uniquely combines opportunities for traditional cataloguing, study, and cosmological interpretation of astrophysical phenomena with laboratory-like examination of basic issues in theoretical physics.

1992 was a year of progress and achievement for the AXAF program. Having completed the first flight mirror pair in September 1991, as a part of the Congressionally-directed mirror demonstration program, design and development of telescope assembly and spacecraft components began in earnest. Development of science instruments and continuing mirror fabrication was performed concurrently with a reexamination of the program in 1992.

In order to improve the ability of the program to respond to future financial pressures, AXAF was restructured into two separate, specialized spacecraft. AXAF-I, a five-year mission to be launched in 1998, will focus on high-resolution imaging and low-resolution grating spectroscopy from high-Earth orbit. AXAF-S, a three-year mission to be launched a year later, will perform high-spectral resolution spectroscopy of high-energy x-ray sources from low-Earth orbit. The original AXAF was conceived as a Shuttle-serviceable, 15-year mission. Both near-term peak funding and long-term operations costs led to this restructuring.

The imaging mission (AXAF-I) will use four nested high-resolution cylindrical mirrors, reduced from the six nested pairs proposed for the original AXAF. Although this will reduce the effective imaging area of the observatory, the reduction is offset by the higher viewing efficiency of the high-Earth orbit. The imaging mission will carry two of the original AXAF instruments, the AXAF CCD Imaging Spectrometer (ACIS) and the High Resolution Camera (HRC), along with two transmission gratings. Overall, this mission will offer an observing efficiency comparable to that of the original AXAF, and retains most of the scientific capabilities, including the ability to measure the important iron line complexes at about six kiloelectronvolts. The latter is an important measure of AXAF, since iron is the most abundant of the heavy elements in the universe and is easily recognized in the x-ray spectrum.

The high-energy spectroscopy mission (AXAF-S) will carry the cryogenically-cooled X-Ray Spectrometer (XRS). A medium-size spacecraft and lower spatial resolution mirror assembly will be used to perform this narrow-band spectroscopy mission. This facility will be launched into a low-Earth orbit selected to simplify thermal control of the cryogenically-cooled instrument. The Marshall Space Flight Center will perform as the spacecraft developer for AXAF-S.

The high, elliptical orbit of AXAF-I from which observation can be performed more efficiently, combined with the dedication of separate spacecraft to AXAF's critical high-resolution imaging and narrow-band spectroscopy missions, insure that the original science goals of AXAF remain intact. AXAF-I's grazing-incidence mirrors, a nested assembly of cylindrical shapes that range from .6 to 1.2 meters in diameter, will provide a factor of two increase in effective imaging area, eight times the angular resolution, and twice the spectral range of HEAO-2.

This set of attributes, combined with advanced coatings which increase the reflectivity of the mirrors, means that AXAF-I will provide a factor of 100 increase in imaging sensitivity for point sources and that AXAF-I and -S together will reap substantial increases both in high-spatial resolution and high-spectral resolution spectroscopy compared to HEAO-2.

This budget submission assumes that AXAF-I will be launched aboard the Space Shuttle, requiring an inertial upper stage and an integral propulsion system to achieve a high elliptical orbit. NASA is currently seeking a proposal for a Titan IV/Centaur system which would be used to launch AXAF-I. This configuration will allow AXAF-I to be placed in a high circular orbit which will improve its observing efficiency. AXAF-S is to be launched aboard a Delta II launch vehicle.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Congressional action reduced AXAF development funding by $7.5 million in FY 1993. This change reduced the amount of near-term financial resiliency that is available in the program, but current work on the spacecraft, instruments, and mirror assembly can remain on schedule. Funding allocations among the spacecraft and instruments reflects current planning for the restructured program.

This adjustment is partially offset by a $1.8 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 constitutes the first year in which significant reductions to the AXAF funding profile will take effect. Preliminary Design Reviews (PDR) will be conducted mid-summer for AXAF-S and for AXAF-I science instruments. Critical Design Audit of the AXAF-I mirror assembly will also occur early in the year. Fabrication of the AXAF-I mirrors will continue at the Hughes-Danbury Optical Systems contractor through FY 1994, leading up to mirror coating activities which will be performed throughout FY 1995. Design of the AXAF-I optical bench and spacecraft system will occur throughout-out the year under the direction of the prime contractor (TRW, Inc.).

AXAF-S will conduct fabrication of parts and assemblies concurrently with design activities. A system-level PDR is scheduled for July 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

GRAVITY PROBE-B DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Gravity probe-b development...........	--	--	1,900	40,000

OBJECTIVES AND STATUS

After a lengthy period of science investigation and technology demonstration, Gravity Probe-B (GP-B) is scheduled to begin development in FY 1993. Using four nearly-perfect spheres spinning at 10,000 rpm, GP-B will measure two predicted relativistic effects in the Earth's gravitational field. Although other tests have been performed of Einstein's general theory since it was developed in the early 20th century, none of these tests have provided an unambiguous verification of the theory. Having received the support of the Space Studies Board of the National Research Council since the early 1980's, GP-B is believed to provide such a test and add to the precision with which general relativistic effects are measured.

General relativity, as opposed to Einstein's special theory of relativity, addresses the effects of the gravity which emanates from large bodies of mass on the space-time continuum. The special theory was a more limited interpretation of how physical measures of space and time are distorted by the relative speeds at which objects or systems move in relationship to one another. This interpretation of experimental evidence about the constancy of the speed of light led to reinterpretations of the amount of energy resident in the physical mass of objects. The general theory extended the special theory in addressing how this distortion may produce the force of gravity.

Results of the GP-B experiment promise to affect the study and interpretation of black holes, quasars, and other astrophysical systems. More importantly, this unique experiment will test a basic theoretical interpretation of the forces of nature which is at odds with the implications of quantum mechanical theory. The GP-B experiment is thereby thought to provide a pathway to a grand unification theory of the forces of nature.

This test of the general theory requires advanced applications in superconductivity, magnetic shielding, precision manufacturing, spacecraft control mechanisms, and cryogenics. The GP-B spacecraft will employ super-precise quartz gyroscopes (small quartz spheres machined to an atomic level of smoothness); coated with a super-thin film of superconducting material (needed to be able to "read-out" changes in the direction

of spin of the gyros); encased in a ultra-low magnetic-shielded, supercooled environment (requiring a complex process of lead-shielding, a large supercooled dewar, and a sophisticated interface among the instrument's telescope, the shielded instrument probe, and the dewar); and maintained with a level of instantaneous pointing accuracy of 20 milliarcseconds (requiring precise star-tracking, a "drag free" spacecraft control system, and micro-precision thrusters).

The combination of these technologies will enable GP-B to measure (1) the distortion caused by the movement of the Earth's gravitational field as the Earth rotates west to east; and, (2) the distortion caused by the movement of the GP-B spacecraft through the Earth's gravitational field south to north, to a level of precision of .2 milliarcsecond per year, the width of a human hair observed from 50 miles.

Demonstration of many of these technologies has already been performed by Stanford University in collaboration with the Lockheed Palo Alto Research Laboratory (LPARL). Following NASA's 1984 review of the status of the GP-B experiment, NASA directed Stanford University to focus on ground test verification of GP-B technologies, augmented by the Shuttle Test of Relativity Experiment (STORE) prior to start-up of a GP-B flight program. Since then, prototype gyroscopes, telescope assemblies, a flight-like probe which surrounds the instrument and telescope, and a laboratory version of a dewar have been subjected to a first round of laboratory testing. Many subcomponent technologies have been designed and evaluated leading up to this initial verification test.

Development of prototype instrument, telescope, and dewar systems, leading to completion of ground verification testing in 1996, will continue as the program transitions to new start activities. Transition to flight article development will begin in FY 1993 following selection of a spacecraft manufacturer.

Under a unique arrangement, GP-B is to be managed by staff of Stanford University, which includes university researchers, professional managers, doctoral candidates, and other student researchers. Close technical collaboration with LPARL for GP-B probe and dewar development and testing will continue. Satellite integration will be performed by a spacecraft manufacturer to be selected under a competitive procurement sponsored by Stanford University. NASA's Marshall Space Flight Center will provide technical and managerial support of the Stanford University project and arrange for GP-B launch services and satellite operations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In accordance with Congressional direction, \$27.0 million was provided for the GP-B/STORE program. \$1.9 million has been provided for initiation of GP-B development in FY 1993, which will enable a spacecraft contractor selection and tests of flight gyroscopes to be conducted. The remainder has been applied to STORE activities which is budgeted in Payload and Instrument Development.

BASIS OF FY 1994 ESTIMATE

In FY 1994, GP-B design activities will begin in earnest. Following selection of a spacecraft contractor in late FY 1993, spacecraft design activities will begin. A spacecraft Preliminary Design Review (PDR) is scheduled to occur in 1995. Development of a flight unit instrument, telescope assembly, probe, and dewar will also commence, leading up to PDR's for the telescope, probe, and dewar in 1994 and 1995. Total development cost of the GP-B is estimated to be $400-440 million, excluding launch vehicle and mission operations/data analysis costs.

BASIS OF FY 1994 FUNDING REQUIREMENT

GLOBAL GEOSPACE SCIENCE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Global geospace science................	75,300	60,100	72,647	13,300
Mission operations and data analysis...	(2,500)	(16,000)	(2,000)	(11,100)
Launch vehicles........................	(28,200)	(15,600)	(3,700)	(8,600)

OBJECTIVES AND STATUS

Global Geospace Science (GGS) is part of the United States' contribution to the International Solar Terrestrial Physics (ISTP) program. This program is an international, multi-spacecraft, collaborative science mission designed to provide the measurements necessary for a new and comprehensive understanding of the interaction between the sun and the Earth. GGS will allow the United States to become a full partner in the ISTP program, reinforcing our commitments to international cooperation and maintaining a leadership role in solar-terrestrial physics.

The GGS is a complementary science mission to the Collaborative Solar Terrestrial Research (COSTR) program under which NASA provides instruments and launch support in exchange for access to science data in a cooperative effort with the European Space Agency (ESA) and the Japanese Institute of Space and Aeronautical Science (ISAS). The combined ISTP program will include eight spacecraft: two U.S. spacecraft, Wind and Polar; five ESA spacecraft, including the Solar and Heliospheric Observatory (SOHO) and four Cluster spacecraft; and one ISAS spacecraft, Geotail. Launch of this suite of systems began in 1992 with the successful launch of Geotail and will be completed in 1995.

The GGS spacecraft will combine their measurements with the Geotail satellite and other Earth observing satellites as the first phase of the ISTP program. The two U.S. spacecraft will use a total of nineteen instruments to make simultaneous measures of the interaction of the solar wind with the Earth's magnetic field, both at the head of the field and as the field surrounds the Earth. GGS will provide the first coordinated geospace measurements of these key plasma source and storage regions, perform multi-spectral global auroral imaging, and provide multi-point study of the Earth's magnetic response to the solar wind. The GGS mission will enhance understanding of how energy and matter from the sun influences Earth's geospace and atmosphere, contributing to assessments of the relationship of

the sun to the Earth's climate. GGS spacecraft contract award was completed in FY 1989, as was final confirmation and initiation of instrument development activity. Wind instruments have completed delivery; mechanical and electrical integration is continuing. Polar instruments are scheduled for delivery in early CY 1993. Wind is scheduled for launch in February 1994; Polar launch is scheduled for May 1994.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding is increased by $11.8 million to support additional requirements due to schedule delays. The launch dates for the Wind and Polar missions have been revised to February 1994 for Wind and May 1994 for Polar. An additional increase of $0.7 million is due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funds will be required to complete development of the Wind and Polar spacecraft, instruments and ground system, and to support activities through 30 days after launch. The Wind spacecraft is scheduled for environmental testing from early 1993 through the summer. After a period of instrument refurbishment, launch preparations are to begin in December 1993.

Polar is scheduled to enter its test program in June 1993 and to complete testing in October. Instrument refurbishment, reintegration, and retest are to precede the beginning of launch preparations in April 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Shuttle test of relativity experiment..	27,200		25,100	2,400
Collaborative solar terrestrial research..........................	62,500	50,300	50,812	25,100
Tethered satellite system.............	3,300	3,300	1,500	--
Astrophysics payloads..................	23,700	23,700	20,728	24,300
Space physics payloads................	1,600	900	1,200	1,600
Total..........................	118,300	78,200	99,340	53,400

OBJECTIVES AND STATUS

Instrument development activities support a wide range of instrumentation. Funds are included for early test, checkout, and design of instruments for long-duration free-flying missions, Shuttle-supported missions, and international flights of opportunity.

The Shuttle Test of Relativity Experiment (STORE), which will provide in orbit testing of GP-B instrument performance, will continue towards its flights aboard the Shuttle in 1995 and 1997. This Shuttle flight article will be used to demonstrate the suspension and high-rate spin properties of high-precision quartz gyroscopes in a low-gravity environment. These gyroscopes constitute the science instrument to be used in the Gravity Probe-B (GP-B) spacecraft.

The Collaborative Solar Terrestrial Research (COSTR) program, in conjunction with NASA's development of the GGS spacecraft, represents the U.S. contribution to the International Solar Terrestrial Physics (ISTP) program. Whereas the GGS program will deploy and operate two U.S. satellites, COSTR provides U.S. instruments for flight aboard foreign spacecraft. The latter include the Solar and Heliospheric Observatory (SOHO), four Cluster spacecraft provided by the European Space Agency (ESA), and the Geotail mission developed by Japan. Geotail was successfully launched in July 1992 and its operation is nominal. The European SOHO and Cluster missions are scheduled for launch in 1995.

The Tethered Satellite System (TSS) was flown aboard the shuttle in July-August 1992. The TSS science program was an international cooperative project with the Italian government. Data analysis activities related to TSS science instruments provided by the U.S. will cease after FY 1993.

Funding for Astrophysics payloads supports development of several instruments designed for flight on the Space Shuttle, including the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS) and Interstellar Medium Absorption Profile Spectrograph (IMAPS), to be flown on the German-U.S. Shuttle Pallet Satellite (SPAS, 1993); ASTRO-2 (1994), a reflight of the ultraviolet portion of the ASTRO-1 (1990) mission; and the Infrared Telescope in Space (IRTS, 1995), a joint U.S.-Japanese mission which will be launched on an expendable launch vehicle and recovered by the Shuttle.

The ORFEUS/IMAPS, which is scheduled to fly aboard the Shuttle in the summer of 1993, will explore the character of extreme and far ultraviolet sources, study the composition and distribution of matter in the neighborhood of the sun, and perform direct observations of the interstellar medium. ASTRO-2 will perform far ultraviolet spectroscopy, broad-band ultraviolet imaging and ultraviolet polarization studies of galactic and stellar phenomena. Integration and test is underway for the IRTS mission, which will survey the sky for cool galactic and intergalactic phenomena across a broad range of the infrared spectrum.

The Astrophysics program also supports a number of ongoing international and U.S. development projects. These include the High Energy Transient Experiment (HETE, 1994), a small satellite for study of gamma-ray burst phenomena in multiple wavelengths; ground-based support for Japan's Very Long Baseline Interferometry Space Observatory Program (VSOP, 1995) and Russia's RADIOASTRON (1997) program; the Stellar X-ray Polarimeter (SXRP) instrument to be flown on Russia's Spectrum-X-Gamma (SXG, 1995) mission; U.S. cooperation on the Infrared Space Observatory (ISO, 1995), a European follow-on to the Infrared Astronomical Satellite (IRAS, 1983); and portions of two instruments to be flown on Europe's X-ray Spectroscopy Mission (XMM, 1998).

The HETE is being managed by the Massachusetts Institute of Technology. As part of its innovative management activities, the university team has obtained an inexpensive satellite from industry, reduced management overhead, relied exclusively on mature technologies, and used contributions from international partners. This mission is to provide information about the precise location of gamma-ray bursters and spectral analysis of these and other high energy transient phenomena.

The VSOP and RADIOASTRON will provide the highest resolution images of radio sources ever obtained. NASA is providing scientific guidance, ground processing hardware, and construction of four ground stations (called NASA's Space Very Long Baseline Interferometer (SVLBI) subnet) to support both missions. With its extremely long baselines, VSOP and RADIOASTRON will explore very small radio sources with high angular resolution, thereby achieving higher resolution of active galactic nuclei and compact radio sources than can be achieved on the ground.

The SXRP instrument will complement other instruments on the Russian SXG mission, providing low resolution polarization data across the x-ray spectrum. Europe's ISO is an observatory with a projected life of 18 months that will provide infrared data for studies of star formation, of other infrared objects and galaxies, and of the infrared background.

The European Space Agency (ESA) XMM satellite is a medium resolution system using highly sensitive instruments providing broad-band study of the x-ray spectrum. This important mission will combine telescopes with heavily nested grazing incidence mirrors and a focal length greater than 7.5 meters with 3 imaging array instruments and two reflective grating spectrometers. The XMM is to have a design life of 10 years.

Space Physics payloads funding will be used to analyze data from instruments flown on the Atmospheric Laboratory for Applications and Science (ATLAS-1, 1992) Shuttle mission through 1993. FY 1993 Astrophysics payload funding will also be used to study this mission's results and the results of the ASTRO-1 mission. The small level of continuing funds for Space Physics payloads will be used to develop instruments for future flight opportunities.

CHANGES FROM 1993 BUDGET ESTIMATE

In accordance with Congressional direction, STORE was funded at $27 million in 1993. $1.9 million of those funds were applied to a new separate line for the start of the GP-B science program.

Also, $3.0 million was transferred from Payload and Instrument Development to Shuttle/Spacelab Mission Management and Integration for preparation for the ASTRO-2 flight in 1994. A reallocation of $0.3 million from the TSS program to Space Physics payloads was made to complete ATLAS-1 data analysis activities. In addition, $1.5 million was transferred from the TSS program to the GGS development program. These adjustments are increased by $0.5 million due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, work will continue on STORE towards its initial launch in 1995. Environmental testing of the STORE flight unit is to be performed in FY 1994.

The COSTR program will provide continuing support for development of the joint ESA-U.S. SOHO and Cluster missions. Flight model instruments for Cluster and SOHO are to be delivered during CY 1993 and integration and checkout activities will occur in Europe prior to launch in 1995.

Under Astrophysics payloads, FY 1994 funding will support data analysis of the 1993 DXS Shuttle payload mission. Support is also provided in FY 1994 for ASTRO-2 Shuttle payload development and conduct of science activities for the 1994 mission. Preparation for the Japanese IRTS mission, which will be returned by the Shuttle in 1995, will also be underway.

Payloads for other U.S. and international missions scheduled to be under development in FY 1994 include the HETE and SXG missions, both scheduled for launch in FY 1995. Support will also be provided in FY 1994 for the ISO mission and for ongoing preparation for the Japanese and Russian radio astronomy missions. Early component design and fabrication will continue for the XMM mission.

BASIS OF FY 1994 FUNDING REQUIREMENT

EXPLORER DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Extreme ultraviolet explorer	6,600	--	--	--
Explorer platform	11,350	--	--	--
X-ray timing explorer	47,400	65,100	65,651	45,600
Advanced composition explorer	--	--	--	28,000
Small explorers	33,654	35,000	36,397	39,400
Other explorers	10,096	12,400	13,784	10,300
Total	109,100	112,500	115,832	123,300

OBJECTIVES AND STATUS

Past Explorers have discovered radiation trapped within the Earth's magnetic field, investigated the solar wind and its interaction with the Earth, studied upper atmosphere dynamics and chemistry, mapped our galaxy in radio waves and gamma-rays, and determined properties of the interstellar medium through ultraviolet observations. Explorers have performed active plasma experiments on the magnetosphere, made in-situ measurements of the comet Giacobini-Zinner, and completed the first high-sensitivity, all-sky survey in the infrared, discovering over 300,000 sources.

Recent missions include the 1992 launch of Extreme Ultraviolet Explorer (EUVE) and the first Small Explorer mission, the SAMPEX.

The X-ray Timing Explorer (XTE, 1996) and two Small Explorer missions are currently under development. The latter are the Fast Auroral Snapshot Explorer (FAST, 1994) and the Submillimeter Wave Astronomy Satellite (SWAS, 1995).

The XTE will use three instruments to conduct timing studies of x-ray sources. An comprehensive record of the source of x-rays with varying intensity over time, characterization of those attributes, and study of compact x-ray emitting objects such as binary stellar masses will be performed by XTE. FAST will provide high resolution data on the Earth's aurora and how electrical and magnetic forces control them. The flow of electrons, protons, and other ions will be studied with greater sensitivity and spatial discrimination and

faster sampling than ever before, using five small instruments. FAST data will be integrated with the results of other Earth observing satellites and ground observations. SWAS will provide discrete spectral data for study of the water, molecular oxygen, and carbon monoxide in dense interstellar clouds, the presence of which is related to the stability of these clouds.

The Advanced Composition Explorer (ACE, 1997) will initiate development in FY 1994. This space physics mission will use nine instruments to study the composition of the solar corona, interplanetary and interstellar media, and galactic matter across a wide range of plasma phenomena. The instruments include six high-resolution spectrometers, designed to improve the collecting power of previous systems, to study the mass and charge of plasma phenomena. Three other instruments will provide measures of the lower energy phenomena related to the solar wind.

NASA's Explorer program also provided telescope mirrors and instrument components for the Japanese Astro-D mission. Astro-D, which was successfully launched on February 19, 1993, will observe x-rays from cosmic sources with emphasis on moderate-resolution imaging and broad-band spectroscopy.

The mid-sized Far Ultraviolet Spectroscopic Explorer (FUSE, 2000) mission is still in the stage of conceptualization.

A second Announcement of Opportunity (AO) for Small Explorer missions was released by NASA in September 1992. Of the 60 proposals received, NASA plans to select three or four in June 1993 for further definition. By May 1994, it is expected that two or three missions will be confirmed for development leading to launches in 1997 through 1998.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The XTE mission was decreased by $1.7 million to provide support required by other Explorer programs, consistent with the integrated management philosophy of the Explorer program. Mission definition activities for FUSE received a portion of these funds, with the remainder applied to Small Explorers. The amount was offset by a $2.2 million increase to XTE, a $0.9 million increase to Small Explorers, and a $0.2 million increase to Other Explorers due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Development activities on the XTE mission will continue in preparation for launch in 1996. Following Critical Design Review (CDR) which will occur in spring 1993, instruments and spacecraft components will be integrated onto the observatory throughout 1994.

The ACE will transition from mission definition to development in FY 1994. Initial design and fabrication of instruments and spacecraft subsystems will commence, leading to a CDR scheduled for late FY 1994.

Development activities, including integration, test and launch preparation for the FAST and SWAS missions will continue in FY 1994 in preparation for launches in 1994 and 1995, respectively.

BASIS OF FY 1994 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
AXAF mission operations and data analysis	3,300	14,900	14,900	11,600
Hubble space telescope operations and servicing	207,700	214,200	216,676	222,200
Hubble space telescope data analysis	36,000	42,300	42,357	38,500
Astrophysics mission operations and data analysis	85,300	100,500	88,268	84,500
Space physics mission operations and data analysis	42,900	69,000	53,184	59,400
Total	375,200	440,900	415,385	416,200

OBJECTIVES AND STATUS

Funds provided to NASA in this program are used to conduct NASA satellite operations and distribute funds among science participants in NASA flight programs for the analysis of satellite data and the conduct of ongoing theory and research programs. Funding is also applied to pre-flight preparations for NASA satellite operations and data analysis activities, and for long-term data archiving and data base services. NASA's MO&DA program supports satellite operations during the performance of the core missions of NASA satellites, extended operations of selected spacecraft, and for ongoing analysis of data after the usable life of spacecraft has expired. In addition, funds from this category are used to support ongoing servicing support for the Hubble Space Telescope (HST).

Pre-launch operations funding for the Advanced X-ray Astrophysics Facility (AXAF) program is to support the development of a ground control system and science center and preparation for flight system operation. A common ground system located at Marshall Space Flight Center will be used to serve the combined requirements for the Space Shuttle, Spacelab, and AXAF flight operations. Both AXAF missions will be supported by a single AXAF Science Center.

Hubble Space Telescope (HST) science operations are carried out through an independent HST Science Institute, which operates under a long-term contract with NASA. Satellite operations, including telemetry, flight operations, and initial science data transcription, is performed on-sight at Goddard Space Flight Center under separate contract. While NASA retains operational responsibility for the observatory, the Science Institute plans, manages, and schedules the scientific operations of the HST. In a single year of operations, the activities of over 500 scientists are supported under the HST program, and over 15,000 observations recorded.

In order to extend its operational life and provide a basis for future enhancements of its scientific capabilities, HST is designed to be serviceable. This requires on-orbit maintenance and changeout of spacecraft subsystems and scientific instruments every few years. In December 1993, the first HST servicing mission is to be performed. This mission will restore the faint object and crowded field capabilities of the telescope which have been unavailable due to spherical aberration of the primary mirror. Also, jitter induced by thermal effects on the observatories solar arrays will be corrected by the installation of two modified solar arrays provided by the European Space Agency. Several subsystems, including system gyroscopes and a data processing system, will be installed so as to restore redundancy and to insure operations until the next servicing mission occurs. Funds are used each year to provide planning and development of instruments for future servicing missions and for development of other components thought to be critical to the reliability of HST. Ongoing modification and upkeep of system ground operations is also performed.

Other satellites developed wholly or in part by NASA are also supported under the Astrophysics and Space Physics mission operations and data analysis programs. Currently, five operational missions in astrophysics and seven operational missions in space physics are supported. Astrophysics missions include the Compton Gamma-Ray Observatory (CGRO, 1991), the Extreme Ultraviolet Explorer (EUVE, 1992), the International Ultraviolet Explorer (IUE, 1978), the Cosmic Background Explorer (COBE, 1989), and U.S. participation in the international Roentgen Satellite (ROSAT, 1990). Space physics missions include the Voyager 1 and 2 (1977), Ulysses (1990), Pioneer 10 and 11 (1972, 1973), Geotail (1992), the SAMPEX (1992), the Japanese cooperative satellite YOHKOH (1991), and the Interplanetary Monitoring Platform (IMP, 1973).

The Compton Observatory measures gamma-rays, which are produced by the most energetic and exotic fundamental physical processes occurring in nature. Instruments on this mission provide unique information on phenomena occurring in quasars, active galaxies, black holes, neutron stars, supernova, and the nature of the mysterious cosmic gamma-ray bursts.

EUVE is studying the sky at wavelengths once believed to be completely absorbed by the thin gas between the stars. Observations at these wavelengths hold the key to understanding the hottest stars in our galaxy and to mapping a "local bubble" of hot and transparent gas in the vicinity of the sun. An all-sky survey lasting six months is completed, and detailed spectroscopic investigation of specific objects is underway.

Early in its operation, the satellite discovered "flares" or explosive events on the surface of at least one extreme ultraviolet star and, despite the obscuring gas, has surprised many by observing sources outside our galaxy.

Space Physics research activities rely on data received from a number of operational spacecraft. The Interplanetary Monitoring Platform (IMP) provides the only measure of solar wind input to the Earth. The Yohkoh spacecraft, a cooperative program with the Japanese, is continuing to gather x-ray and spectroscopic data on solar flares, irradiance, and oscillations. Ulysses is on its way to study the sun's polar regions, measuring the interplanetary medium and solar wind as a function of heliographic latitude, having been swung out of the plane of the ecliptic by the gravity of Jupiter. Voyager 1 and 2 and Pioneer 10 and 11 are continuing to look for the heliospheric boundary with interstellar space as they travel beyond the planets. The SAMPEX is measuring the composition of solar energetic particles, anomalous cosmic rays, and galactic cosmic rays. Geotail, a Japanese spacecraft which is the first part of the cooperative International Solar Terrestrial Physics (ISTP) program, is studying the Earth's magnetotail.

Support for future missions is also included under the Physics and Astronomy MO&DA program, including U.S.-developed and launched satellites, payloads orbited under the Shuttle/Spacelab program, and U.S. participation in international programs.

CHANGES FROM FY 1993 BUDGET ESTIMATE

A $12.6 million reduction was applied to astrophysics satellite operations and data analysis as part of the $20 million Congressional general reduction. The main impact was a major reduction in support to university researchers.

The $7.4 million reduction to space physics programs resulted in earlier-than-planned termination of International Cometary Explorer (ICE) routine operations, and Dynamics Explorer (DE) and Active Magnetospheric Particle Trace Explorer (AMPTE) data analysis. Funding for participation in various international mission activities was also eliminated. Another $8.8 million was transferred from Space Physics MO&DA to GGS Development due to launch schedule changes in that program.

These adjustments are partially offset by a $2.6 million increase to HST operations, servicing, and data analysis; and a $0.8 million increase to Astrophysics and Space Physics MO&DA due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 will support ongoing operation of NASA spacecraft: data analysis for current and previously operational satellites; support for astrophysics data archiving, data management, and theory programs; and development of ground systems and science operations for future spacecraft. Future servicing needs of the HST are also supported.

The AXAF MO&DA funds will support the ongoing development of unique ground system elements of the AXAF program and documentation of ground control operations. Preliminary Design Review of AXAF mission operations will be held mid-year, supported by preliminary reviews of off-line ground system software, a ground system simulator, and the AXAF Science Center; and Critical Design Review of the on-line ground data system.

FY 1994 funds for the HST will support the first servicing mission, continue preparations for future servicing missions, support ongoing development of ground systems and ground system operations, and conduct mission operations and data analysis for the Hubble system. Preparation for flight, including conduct of the Flight Readiness Review for the first servicing mission and final integration of HST servicing equipment with the Shuttle, flight operations for the mission, and ground operations during and after servicing are all to be performed in early FY 1994. Limited interruption of science operations is planned while initial calibration and test of the new HST configuration is performed. HST operations and servicing funds will also support development of the Near Infrared Camera (NIC) and Space Telescope Imaging Spectrograph (STIS) instruments to be flown on future servicing missions, and ongoing development and maintenance of HST components and subsystems needed to perform future telescope maintenance. As ongoing ground and science operation of the telescope is performed, changes to flight system software and ground system software, hardware, and operations protocols will continue.

HST data analysis funds will support the completion of a data archiving system; continuance of the activities of the Guaranteed Time Observers program, composed of science instrument teams and designated observatory scientists; and expansion of the Guest Observer and Archival Researchers programs.

In FY 1994, Astrophysics MO&DA will fund operation and data analysis activities for the CGRO, EUVE, IUE, COBE, and ROSAT astrophysics missions. Funds are also provided for the continuation of support for the Japanese Astro-D mission and for initiation of operations of the High Energy Transient Experiment (HETE).

Space Physics MO&DA will support the operation and data analysis for the Voyager, Ulysses, Pioneer, Geotail, SAMPEX, Yohkoh, and IMP space physics missions. Support for the GGS mission is included in FY 1994 for the initiation of Wind and Polar operations.

The remainder of Astrophysics MO&DA funds will support data archiving, dissemination, and theory programs. Data analysis and archiving activities will continue for the High Energy Astrophysics Observatories (HEAO) which ceased operation in 1981 and the Infrared Astronomical Satellite (IRAS) which ceased operation in 1983. The recently-established Astrophysics Data System and other archiving systems will also continue to provide scientific users access to NASA's astrophysics data. Astrophysics MO&DA funds also support theoretical research of topics broader than those typically supported under Research and Analysis funding.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Space physics supporting research and technology	36,237	43,400	37,257	37,800
Astrophysics supporting research and technology	33,700	38,000	34,301	34,400
Total	69,937	81,400	71,558	72,200

OBJECTIVES AND STATUS

The objectives of the Supporting Research and Technology (SR&T) program funded under Research and Analysis are to: (1) optimize the design of future missions through science definition, development of advanced instruments and concepts, and definition of proposed new missions; (2) strengthen the technological base for sensor and instrument development; (3) enhance the value of current space missions by carrying out ground-based observations and laboratory experiments; (4) conduct the basic research necessary to understand astrophysics phenomena and solar-terrestrial relationships and develop theories to explain observed phenomena and predict new ones; and, (5) continue the acquisition, analysis and evaluation of data from laboratories, airborne observatories, balloons, rocket and spacecraft activities.

Astrophysics program activities in the areas of gamma-ray, x-ray, ultraviolet, visible light, infrared, submillimeter, and radio astrophysics are supported with these funds. Space Physics researchers in the disciplines of magnetospheric, ionospheric, cosmic ray, and solar physics are also supported.

In Astrophysics, both the Explorer and Great Observatories programs rely upon accomplishments of the SR&T program for technology development and instrument design to achieve planned science objectives. Current emphasis is being placed on studies of advanced instruments and detectors with increased sensitivity and resolution.

Space physics research and analysis is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in the solar corona, the interplanetary medium and in the vicinity of the Earth and other planets. Recent thrust is directed at studies of the near-Earth geospace

environment, from the flow of the solar wind past the magnetosphere to variations of the plasma environment near the surface of the Earth. These studies have many practical implications, such as determining disruptive effects on communications, analyzing the impact of solar input on the global circulation of the Earth's upper atmosphere, or examining space plasma effects on spacecraft.

In addition to supporting basic and experimental astrophysics research for future flight missions, the SR&T program develops and promotes United States scientific and technological expertise. The SR&T program carries out its objectives through providing grants to universities, nonprofit and industrial research institutions, and funds to scientists at NASA Centers and other government agencies. Several hundred grants are awarded each year to the community of scientists. These grants help train future investigators in astrophysics and space science disciplines -- science and engineering graduate and post graduate students who will become the Nation's future scientific leaders.

NASA also allocates SR&T funds to Advanced Technology Development (ATD) programs. ATD is used to develop new mission concepts and to ensure that the technology for a mission is mature before development begins in order to minimize cost, schedule, and technical risks. Mission concept and definition studies are used to identify and define new and usable technologies and optimize their use within an affordable development cost. Increasing emphasis is being made within the Agency to better utilize advanced technologies in future missions.

The Astrophysics ATD program will continue to support definition studies for the Stratospheric Observatory for Infrared Astronomy (SOFIA), an airborne-observatory intended to replace the current NASA airborne astronomy system, and early studies of space infrared technologies. All other mission definition studies have been eliminated.

Space Physics SR&T activities include continuing definition studies of the Thermosphere, Ionosphere, Mesosphere Energetic and Dynamics (TIMED) mission and the High Energy Solar Physics (HESP) mission.

<u>CHANGES FROM FY 1993 BUDGET ESTIMATE</u>

Research and Analysis program funding has been reduced by a total of $11.0 million, consistent with Congressional direction. As a result, some ongoing activities have been terminated, and no new activities have been initiated this fiscal year. This reduction is offset by a $1.2 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

During FY 1994, the Astrophysics and Space Physics R&A program will continue to support its activities at approximately the same level as FY 1993, including the continuation of support for mission concept studies for the SOFIA, TIMED, and MESP candidate missions.

BASIS OF FY 1994 FUNDING REQUIREMENT

SUBORBITAL PROGRAM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Airborne science and applications......	12,000	12,600	13,014	13,600
Balloon program........................	13,900	15,400	15,437	16,400
Sounding rockets.......................	34,200	37,300	36,392	39,500
Total..........................	60,100	65,300	64,843	69,500

OBJECTIVES AND STATUS

The suborbital program uses aircraft, balloons, and sounding rockets to conduct versatile, relatively low-cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a national and international cooperative basis.

Research with instrumented jet aircraft has been an integral part of the NASA Physics and Astronomy program since 1965. Quick response to "targets of opportunity" is able to be conducted at relatively low cost. The airborne science and applications program operates the Kuiper Airborne Observatory (KAO) for astronomy research.

The KAO facility consists of a C-141 aircraft equipped with a 91-centimeter infrared telescope. The C-141's ability to fly for several hours at altitudes approaching 13 kilometers allows cloud-free astronomical observations to be made. This altitude also allows for infrared observations, which are not absorbed by atmospheric water vapor at this altitude. This has been essential in expanding astronomical observations into the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers.

In FY 1992, the C-141 conducted one major campaign in the Southern Hemisphere to continue studies of the Supernova SN1987A, the nearest visible supernova to occur in modern times, and observations of the galactic center. The KAO is currently the only facility in the world that can conduct these observations in the far infrared and submillimeter wavelengths. Infrared observation of Mars, Pluto, and Jupiter also continue to provide important scientific return.

The Balloon program provides a cost-effective means to test flight instrumentation in the space radiation environment and to make observations at altitudes which are above most of the water vapor in the atmosphere. In many instances it is necessary to fly primary scientific experiments on balloons, because of size, weight, or cost considerations or lack of other opportunities.

Balloon experimentation is particularly useful when studying infrared, gamma-ray, and cosmic-ray astronomy. In addition to the level-of-effort science observations program, significant emphasis has been and will be placed on development of a balloon capable of lifting more than 3,500 pounds. In addition, the balloon program is now capable of conducting a limited number of missions lasting several days; successful long-duration flights have been conducted in the Antarctic, and more are planned.

A major objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurora and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the sun, stars and other celestial objects.

In addition, the sounding rocket program provides several science disciplines with the means for flight testing of instruments and experiments being developed for future flight missions. The program also provides a means for calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft.

Support for Spartan missions aboard the Shuttle is also included. Spartan 201 consists of a 17-inch diameter solar telescope with an ultraviolet coronagraph and a white light coronagraph to observe and measure the solar source of the solar wind. Spartan 201 is planned for Shuttle launch in 1993, with reflight in 1994 and 1995 to provide correlative data for the Ulysses mission during its passage over the solar poles.

CHANGES FROM FY 1993 BUDGET ESTIMATE

$1.5 million was transferred from the sounding rocket program to the GGS development program. In addition, a $1.0 million increase occurred due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, the Airborne Science and Applications funding will be used to continue flight missions utilizing the capabilities of the KAO.

Balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery as well as for maintenance and operations of the National Scientific Balloon Facility (NSBF) at Palestine, Texas, and other remote launch sites. Funding for the experiments flown on balloons is provided from research and technology funds which support the various scientific disciplines. Balloon program funding will continue to support up to 40 missions per year.

FY 1994 funds will also provide for the vehicles, hardware, integration, launch site maintenance, etc. to assure continuation of the sounding rocket and Spartan programs. Funding will continue to support up to 40 rocket flights per year. The Spartan program will support the planned reflights of Spartan 201.

BASIS OF FY 1994 FUNDING REQUIREMENT

INFORMATION SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Information systems....................	--	--	--	26,500

OBJECTIVES AND STATUS

Beginning in FY 1994, support for NASA's Information Systems program will be divided between the Mission to Planet Earth program and the Physics and Astronomy program. Physics and Astronomy will support three of the four areas of application, development, and research in advanced computing applications: science data management and archiving, science networking, and information systems research and analysis. Multiple science disciplines will be supported by the projects funded under this program.

NASA's National Space Science Data Center (NSSDC) archives and distributes data acquired in space flight programs. A master directory service for distribution of science data to a wide range of users is also maintained. In addition, support is provided for development of search techniques to access data from multiple data bases and to assimilate data from multiple data sets into single applications.

The NASA Science Internet is a computer networking service used to provide research access to flight program data bases, data processing systems, and to applications for scientific collaboration. Researchers and organizations participating in NASA-funded flight programs and in joint international missions are supported by this capability. This capability continues to expand in response to increased requests for access, and is closely coordinated with other U.S. computer networking facilities.

Funds provided for information system research and technology is used to improve science data management, analysis, and visualization techniques to improve scientists' productivity. A NASA Research Announcement is to be released in 1993 for continuing investigation in these areas.

BASIS OF FY 1994 ESTIMATE

Beginning in FY 1994, Physics and Astronomy funding for the Information Systems program will support the continued operation of the NSSDC to distribute science data assets. Development of master directory services and data exchange standards for enhanced inter-operability among distributed and heterogeneous data bases will be emphasized. Science data networking needs will be improved with the NASA Science Internet, allowing more users access to the network consistent with flight program requirements.

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE | **PLANETARY EXPLORATION**

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Mars observer	85,000	--	--	--	RD 4-1
Mars balloon relay	1,200	--	--	--	
Mars '94	--	--	3,500	3,500	RD 4-7
Cassini development	210,700	210,000	204,953	266,600	RD 4-9
Mission operations and data analysis	160,721	170,300	163,482	160,700	RD 4-12
Research and analysis	76,600	106,900	101,680	126,400	RD 4-15
Total	534,221	487,200	473,615	557,200	

Distribution of Program Amount by Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Johnson Space Center	12,900	13,700	13,700	14,100
Marshall Space Flight Center	800	1,000	1,000	1,200
Goddard Space Flight Center	11,900	23,600	24,575	30,300
Jet Propulsion Laboratory	399,521	320,700	311,400	367,300
Ames Research Center	17,100	10,400	10,647	22,400
Langley Research Center	650	700	713	800
Headquarters	91,350	117,100	111,580	121,100
Total	534,221	487,200	473,615	557,200

OBJECTIVES AND JUSTIFICATION

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system; (2) to understand the Earth better through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and, (4) to provide a scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been highly successful based on a strategy that places a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the smaller bodies (comets and asteroids). Missions to previously unexplored solar system bodies typically start at the level of reconnaissance to achieve a fundamental characterization of the bodies. Subsequent missions then conduct more detailed studies.

With the Magellan mapping of the Venusian terrain, the reconnaissance phase of inner planetary exploration, which began in the 1960's, is virtually complete. Through the Magellan and Pioneer-Venus missions, we have now obtained a basic characterization of Venus' atmosphere as well as fundamental data about the formation of the planet. Magellan, which was launched in April 1989, arrived at Venus in August 1990 and began providing global maps of the cloud-shrouded surface of Venus, including its land forms and geological features. Using a Synthetic Aperture Radar (SAR) to penetrate the planet's opaque atmosphere, Magellan provides a resolution sufficient to identify small-scale topographical features that address fundamental questions about the origin and evolution of the planet. Magellan has successfully mapped 99 percent of the surface of Venus. Radar and altimetry data acquisition are also completed. The spacecraft is currently obtaining gravity data to accurately determine the planet's gravity field and the internal stresses and density variations so that the evolutionary history of Venus can be compared with that of Earth. Mission operations are planned for termination in May 1993.

Mars has been a primary program focus due to its potential for previous biological activity and as a site for future human missions. The Viking landings in 1976 carried the exploration of Mars forward to a high level of scientific and technological achievement, thereby setting the stage for the next step of detailed study, the geologic and climatological mapping of the planet by Mars Observer, launched in September 1992. New insights into the Martian system are anticipated when the spacecraft arrives at Mars in August 1993. Mars Observer will build upon the earlier discoveries of the Mariner-9 and Viking missions with emphasis on the geologic and climatic evolution of this complex planet. The Mars Observer spacecraft will also support

mission operations for Mars '94, a Russian mission with international cooperation. French-supplied electronics aboard the Mars Observer will relay data from the landers and balloons to be carried by the Russian Mars '94 mission. Funding is also provided in FY 1993 and FY 1994 to provide up to two U.S. instruments for flight aboard the two landers which will fly on the Russian Mars '94 mission as well.

While studies of the inner solar system were initiated in the early 1960's, reconnaissance of the giant outer planets began more recently. The Pioneer-10 and -11 missions to Jupiter in 1973 and 1974 were followed by the Voyager-1 and -2 spacecraft encounters in 1979. Voyager-1 then encountered Saturn in November 1980, with Voyager-2 following in August 1981. The Voyager data on these planets, their satellites, and their rings revolutionized concepts about the formation and evolution of our solar system. Voyager-2 flew by Uranus in January 1986, providing our first close look at this giant outer planet. Its trajectory carried it to an encounter with Neptune in August 1989, which provided spectacular images of this mysterious planet and its satellites. In February 1990, Voyager-1 took the first composite photograph of our solar system. Detailed studies of outer solar system bodies will commence with Galileo.

Galileo was launched in October 1989. In October 1991, the spacecraft flew by Gaspra, obtaining the first detailed images ever obtained of an asteroid. Additional images were played back when Galileo again flew close to Earth in December 1992. In August 1993, the spacecraft will return images of Ida, a second asteroid, en route to Jupiter. Upon arrival at Jupiter in December 1995, the comprehensive science payload will extend our knowledge of the Jovian system well beyond the profound discoveries of the Voyager and Pioneer missions. During twenty-two months of operation, Galileo will inject an instrumented probe into Jupiter's atmosphere to make in-situ measurements while the orbiter will have the capability to make as many as ten close encounters with the Galilean satellites. Failure to fully deploy the High Gain Antenna (HGA) will require the mission to be conducted using only the Low Gain Antenna (LGA) for spacecraft telemetry and data down link. Planning is currently underway to determine the changes in mission design and Deep Space Network (DSN) coverage to support the new mission requirements.

Cassini will continue our detailed studies of the outer solar system by conducting extensive investigations of Saturn and its satellites. In conjunction with spacecraft observations, the European Space Agency (ESA)-provided Huygens Probe will conduct in-situ atmospheric measurements of Saturn's moon Titan. Building upon the discoveries made through the Pioneer and Voyager missions, Cassini will provide new understanding into the origin of the solar system and will help determine whether the necessary building blocks for the chemical evolution of life exist elsewhere in the universe. In an effort to reduce total program costs and improve mass and schedule margins, the program has been restructured. Despite significant changes to the spacecraft design, the science payload remains essentially intact. All technical and programmatic changes have now been approved, and development activities are underway with no change in the planned launch in October 1997 aboard a Titan IV launch vehicle. En route to Saturn, the spacecraft will fly by Earth, Venus, and Jupiter to gain sufficient acceleration to reach Saturn in June 2004. Upon arrival, the spacecraft will conduct extensive investigations of the Saturnian system for four years.

In addition to the development of new missions, ongoing Mission Operations and Data Analysis (MO&DA) activities are a major focus of the Planetary Exploration program. Extensive effort continues in support of the Voyager-Neptune, Galileo, Magellan, and Mars Observer missions. Activities include the monitoring of spacecraft operations, ongoing mission design and software development, and acquisition/processing/analysis of new data as it is acquired. Ongoing data analysis of existing data sets are also conducted. Planetary flight support activities provide continuous design, development and maintenance of ground support hardware and software for mission control, telemetry and command functions for all planetary spacecraft still in operation.

The Research and Analysis (R&A) program continues to define the scientific priorities for future missions as well as maximizing the exploitation of existing data sets. Advanced program activities provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. The instrument definition program ensures maximum scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation. The Mars Data Analysis program continues to support analysis of data obtained by Viking and earlier missions so that we are scientifically prepared for the next phase of Mars exploration. Establishment of a Planetary Data System (PDS), which will permit the archiving of these and all other data products in a manner promoting and facilitating their use, is also supported. The High Resolution Microwave Survey (HRMS) program uses radio astronomy facilities and Deep Space Network (DSN) antennas to analyze microwave signals in space for technological evidence of intelligent life beyond our solar system. The Exobiology program has been transferred from Life Sciences to Planetary R&A beginning in FY 1994 to more accurately reflect the nature of the research conducted. Exobiology research is directed toward understanding the origin and distribution of life, and life-related molecules on Earth and throughout the universe.

BASIS OF FY 1994 FUNDING REQUIREMENT

MARS OBSERVER DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	42,700	--	--	--
Experiments	36,000	--	--	--
Ground operations	6,300	--	--	--
Total	85,000	--	--	--
Mars balloon relay experiment	1,200	--	--	--
Mission operations and data analysis	--	(45,600)	(40,526)	(34,300)
Launch vehicle	(32,600)			
Upper stage	(6,800)	(200)		

OBJECTIVES AND STATUS

The objectives of the Mars Observer mission are to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation, topography, gravity and magnetic fields of Mars. The mission will also determine the presence of volatile chemical constituents in the atmosphere and soil and observe their interaction with the Martian environment during all four seasons of the Martian year.

Mars Observer was launched in September 1992 on a Titan III/Transfer Orbit Stage (TOS) launch vehicle. The spacecraft is currently en route to Mars and will arrive in August 1993. Operations to date have been nominal. All cruise deployments as well as initial spacecraft and science instrument checkouts are now-completed. Upon arrival, the spacecraft will be inserted into a near-polar Martian orbit from which it will carry out geochemical, geophysical, and climatological mapping of the planet over a period of approximately one Martian year, which is nearly two Earth-years. The Mars Balloon Relay (MBR) experiment will permit a significant increase in the amount of data returned from the landed stations of the Russian Mars '94 mission. Using French-supplied electronics carried aboard the Mars Observer spacecraft, MBR data will be incorporated into the Mars Observer Camera (MOC) data stream for transmission to Earth. MBR operations will be initiated near the conclusion of the Mars Observer nominal mission in 1995.

FY 1993 activities will be focused on concluding the checkout of all flight hardware and science instruments before arrival at Mars and establishment of the final mapping orbit. Also, flight software updates and ground data system implementation for transition from cruise to prime mission operations in FY 1994 will be accomplished. Plans for science data archiving and the disposition of flight spare hardware are also underway.

BASIS OF FY 1994 FUNDING REQUIREMENT

MARS '94

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mars '94	--	--	3,500	3,500

OBJECTIVES AND STATUS

The Mars '94 mission is a Russian mission comprised of an orbiter and two soft landers which will be deployed on the Martian surface. Each lander will carry a variety of science instruments provided by several international partners including Germany, Finland and France. These include descent and surface imagery, in-situ seismology and meteorology measurements. In addition to the Mars Observer/MBR support, this funding augments U.S. participation in the mission by providing instruments for flight aboard the landers.

The original arrangement was for the Russians to expand their original launch configuration from two landers to three, with the U.S. to provide two instruments for flight aboard the third lander. To avoid significant hardware redesigns, the Russians subsequently decided not to fly a third lander. However, U.S. participation in the mission is still planned. The current plan is for the U.S. to provide two soil oxidation instruments, one for flight aboard each of the two original landers. To conserve mass, power, and space, these experiments will share common electronics subsystems with German and Russian instruments. The U.S. instruments will determine the presence of atmospheric and/or soil oxidants which theoretically caused the rapid destruction of the organic material tested on the Viking mission. The instruments will be shipped to Helsinki, Finland in late 1993 for integration into the total science payload complement. The scheduled launch date is November 1994 aboard a Russian Proton launch vehicle. The U.S. will be given access to all science data from the Mars '94 mission within one year. U.S. scientists are also involved on nearly all other science instruments as well.

CHANGES FROM FY 1993 BUDGET ESTIMATE

No funds were originally requested for this initiative in the FY 1993 budget since initial planning was not conducted until last July-August. Funding has been reallocated from Mars Observer mission operations and Voyager-Neptune data analysis, in accordance with NASA's initial FY 1993 operating plan. FY 1993 funds will support detailed design and fabrication activities in coordination with international partners.

BASIS OF FY 1994 ESTIMATE

FY 1994 funds will support final integration and testing of the two U.S. science instruments. These instruments will be delivered to Helsinki, Finland in November 1993 for electrical integration with the rest of the science payload. After initial testing, the payload will then be shipped to Russia in December 1993 for final integration and testing with the Russian spacecraft.

BASIS OF FY 1994 FUNDING REQUIREMENT

CASSINI DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spacecraft	134,000	122,700	122,700	168,500
Experiments	68,500	76,800	76,800	81,500
Ground operations	8,200	10,500	5,453	16,600
Total	210,700	210,000	204,953	266,600
Launch vehicle	(20,100)	(9,300)	(5,278)	(82,300)

OBJECTIVES AND STATUS

During the 1970's, our Nation established scientific and technological leadership in exploration of the outer solar system with successful launches of Pioneers 10 and 11 and Voyagers 1 and 2. The Cassini mission will maintain our leadership in solar system exploration. Building upon the earlier discoveries of Pioneer and Voyager, Cassini's study of the Saturnian system will greatly improve our understanding of the early evolutionary processes which formed our entire solar system. The Cassini targets (asteroids, Titan, and Saturn system) have a common origin in the outer solar system. The icy conditions on these bodies preserve a record of different stages and processes occurring during solar system formation and evolution. Analysis of their structure and composition may help determine whether the necessary building blocks for the chemical evolution of life exist elsewhere in the universe. In conjunction with Galileo's study of the Jovian system, the mission should also provide much insight as to how and why the large, gaseous outer planets have evolved much differently than the inner solar system bodies.

Cassini is scheduled for launch in October 1997 aboard a Titan IV launch vehicle. An extensive cruise period is required to reach Saturn, requiring the spacecraft to fly by Venus, Earth, and Jupiter to gain sufficient velocity to reach its destination. Upon arrival in June 2004, the spacecraft will begin four years of study of the Saturnian system which will provide intensive, long-term observations of Saturn's atmosphere, rings, magnetic field, and moons. In conjunction with the observations conducted by the spacecraft, the ESA-provided Huygens Probe will be injected into the atmosphere of Saturn's moon Titan, to conduct in-situ physical and chemical analyses of its methane-rich, nitrogen atmosphere which is a possible model for the pre-biotic stage of the Earth's atmosphere. The Cassini spacecraft will also obtain a radar map of most of Titan's surface.

In an effort to reduce total program costs, mass and power requirements, an extensive restructuring exercise was conducted in 1992. These objectives were achieved without significantly impacting the spacecraft design or deleting any of the science instruments. Major mass savings were achieved by deleting spacecraft instrument booms in favor of instrument pallets mounted directly onto the spacecraft structure. Onboard propellant tanks were reduced in size to meet Cassini-unique requirements since the tanks were originally sized to accommodate Comet Rendezvous/Asteroid Flyby (CRAF) requirements as well. These measures will not only reduce total spacecraft mass by approximately 1,400 kg (> 3,000 lbs), but reduce peak power and thermal control requirements as well. Significant cost savings will be achieved by reductions in spacecraft test hardware in favor of a protoflight approach in which the flight model structure will be used for all integrated test activities. Additional savings are achieved by reducing spare hardware and reverting to class B parts wherever possible on both the spacecraft and instruments. Consistent with these changes, the Jet Propulsion Laboratory (JPL) is also committed to reducing total workforce requirements by reducing contractor oversight, delegating authority to lower-level managers, and reduced hardware fabrication and test requirements due to the new protoflight approach.

The restructured program has now been approved by NASA management, and implementation of the proposed changes is well underway. A system-level Critical Design Review (CDR) was completed in December 1992, and fabrication of the redesigned hardware is being initiated. Revised management approaches are being undertaken to streamline requirements and delegate authority to lower-level managers. Project personnel have been consolidated at JPL to optimize communications and expedite administrative functions.

Total program costs are further reduced by transferring the Advanced Multimission Operations System (AMMOS) development from Cassini to the Planetary Mission Operations and Data Analysis (MO&DA) budget. The AMMOS activity will develop ground system software which provides an integrated picture of the status of spacecraft systems, thereby reducing the workforce levels required for mission operations. Although originally funded as a Cassini-unique requirement, development of this capability will benefit other future planetary missions as well. These combined actions have reduced total development costs by approximately $300 million, with the majority of savings achieved in the FY 1994-FY 1995 time frame. The October 1997 launch date remains unchanged.

CHANGES FROM FY 1993 BUDGET ESTIMATE

$5.6 million was transferred from Cassini to the Planetary MO&DA (Flight Project Support) budget, in accordance with the FY 1993 initial operating plan. These funds support the AMMOS ground system upgrade which is no longer funded as a Cassini-unique activity. Funding is increased by a $0.5 million reallocation of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funding supports the continuation of detailed design activities for the majority of spacecraft subsystems. CDRs are planned for the Radio Frequency Subsystem (RFS), Low Gain Antenna (LGA), Attitude and Articulation Control System (AACS), and a joint CDR will be held with Germany for the propulsion system. Concurrently, most spacecraft subsystem elements will begin initial hardware fabrication and integration.

Similar activities will be conducted for the science payload. All remaining CDRs will be completed by mid-FY 1994, and hardware fabrication will be initiated. Fabrication of engineering models (EM) for the two U.S.-provided Huygens Probe instruments will be completed and delivered to ESA by mid-FY 1994. The probe Hardware Design Review (HDR) will also be conducted in early FY 1994. Preliminary Design Reviews (PDRs) and CDRs are scheduled for all major elements of the ground system, culminating with a system-level CDR in late 1994. Funding also will be provided to the Department of Energy (DOE) for their ongoing Radioisotope Thermoelectric Generator (RTG) development activities in support of the Cassini mission. A Preliminary Safety Analysis Review (PSAR) of this system is also planned for 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Galileo operations....................	57,700	63,000	59,429	57,600
Magellan operations...................	45,100	7,000	7,000	5,100
Mars observer operations..............	--	45,600	40,526	34,300
Pioneer programs......................	10,600	--	--	--
Voyager-Neptune data analysis.........	4,300	6,000	5,010	5,700
Planetary flight support..............	43,021	48,700	51,517	58,000
Total...........................	160,721	170,300	163,482	160,700

OBJECTIVES AND STATUS

The objectives of the planetary Mission Operations and Data Analysis (MO&DA) program are in-flight operation of planetary spacecraft as well as the acquisition and analysis of data from these missions. The planetary flight support activities are those associated with the design and development of planetary ground operation systems for multiple missions, and other activities that support the mission control, tracking, telemetry, and command functions through the Deep Space Network (DSN) for all planetary spacecraft.

Operations for Galileo began in October 1989 for the spacecraft's 6-year journey to Jupiter. The spacecraft passed by Earth last December for the second and last time as it departed the inner solar system. Since launch, the spacecraft has returned the first detailed images ever obtained of an asteroid -- Gaspra. Galileo will encounter a second asteroid, Ida, in August 1993. Failure to deploy the High Gain Antenna (HGA) requires a rebaselining of the mission for use of the Low Gain Antenna (LGA) only. Planning is underway to determine changes in mission design and DSN coverage to support the new mission requirements.

The Magellan spacecraft was launched in May 1989. Since its arrival at Venus in August 1990, the spacecraft's radar has mapped approximately 99 percent of the planet's surface to a ground resolution of about 150 meters. Although mapping activities are complete, mission operations continue through May 1993 as the spacecraft obtains detailed gravity measurements which, when studied in coordination with radar mapping data, will help determine the internal geological processes responsible for much of the planet's topography. Extensive data processing and analysis of existing radar data sets are underway as well.

Data analysis from the Voyager-2 Neptune encounter of August 1989 continues. This flyby of Neptune provided our first detailed images of this distant planet, as well as previously unknown moons and geyser-like surface eruptions.

Mars Observer mission operations began in October 1992 when the spacecraft was launched aboard a Titan III with a Transfer Orbit Stage (TOS) upper stage. The spacecraft will arrive at Mars in August 1993 for a two-year prime mission, followed by support of the Russian Mars '94 mission through early FY 1996.

Pioneer mission operations funding and responsibility was transferred to Physics and Astronomy MO&DA beginning in FY 1993, and is ongoing.

Planetary flight support provides ground system development and support for all planetary missions. Efforts are underway in FY 1993 to initiate the Advanced Multimission Operations System (AMMOS). This ground system upgrade will improve our ability to monitor spacecraft systems, and is designed to reduce workforce levels and increase operations efficiencies for Cassini and other future planetary missions.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Total MO&DA has been reduced by $6.9 million due to the Congressionally-directed general reduction of $9.0 million, the reallocation of $3.5 million to support the Mars '94 mission, and the transfer of $5.6 million for the AMMOS activities from Cassini development to Planetary Flight Support. Funding reductions have been accommodated by reducing program flexibility in Galileo and Mars Observer operations, Voyager-Neptune data analysis and Planetary Flight Support activities. The $5.6 million AMMOS transfer initiates development of ground system upgrades which will improve operating efficiencies for future planetary missions, starting with the Cassini mission. Total funding is increased by $0.1 million due to the reallocation of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Mission operations, ground system and flight software development activities for Galileo will continue in support of probe release in July 1995 and arrival at Jupiter in December 1995. Failure to deploy the HGA will also require significant changes to mission planning and flight software development activities to accommodate transition to a LGA mission.

Mars Observer prime mission operations will begin in early FY 1994 and will continue through FY 1995 and beyond. Funding will support mission operations and engineering teams which monitor the spacecraft and develop command uplink software for mapping activities. Funds will also support the acquisition and processing of science data as well as the science team data analysis activities.

Magellan mission operations are scheduled for termination in FY 1993. FY 1994 funding for Magellan supports continued science investigations and analysis of existing data sets only. Ongoing support for the Voyager-Neptune data analysis program will continue.

Planetary Flight Support funding supports the development of ground system capabilities required for Galileo and Mars Observer prime mission operations. Additional ground system development will continue in preparation for the Cassini launch in October 1997. Development of the AMMOS ground system upgrade will also continue with further software development and testing activities leading to operational capability in time for Cassini and subsequent planetary missions.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology.....	69,500	81,500	59,160	87,600
Advanced programs.....................	7,100	25,400	30,433	16,000
Toward other planetary systems (TOPS)..	--	--	12,087	12,300
Exobiology............................	(9,384)	(9,400)	(9,230)	10,500
Total............................	76,600	106,900	101,680	126,400

OBJECTIVES AND STATUS

The Research and Analysis (R&A) program consists of three elements to: (1) assure that data from flight missions is fully exploited: (2) undertake complementary laboratory and theoretical efforts: and (3) define science rationale and develop required technology to undertake future planetary missions.

Supporting Research and Technology (SR&T) funds provide resources for basic and applied research activities across a wide variety of planetary science disciplines. Planetary astronomy includes all observations made by ground-based telescopes of solar system bodies, with emphasis on outer planets, comets, and asteroids. The data acquired is used both for basic research in support of planetary program objectives and for direct support of specific flight missions. Funding also supports continued operation of the Infrared Telescope Facility (IRTF) in Hawaii. Planetary atmospheric research studies the properties of other planetary atmospheres which can aid us in better understanding our own weather and climate. Observations of the atmospheres of Venus, Jupiter, Saturn, Uranus, and Neptune acquired by Pioneer Venus and Voyager, have laid the basic observational groundwork for major advances in this field.

Planetary geology/geophysics activities include the study of surface processes, structure, and history of solar system bodies. Comparative studies provide a fundamental understanding of the physical processes which control the development and evolution of all planetary bodies, including the Earth. In this respect, data from the Magellan mission is of crucial importance. Planetary materials/geochemistry activities study the chemistry, composition, age, and physical properties of solid material in the solar system through the

study of returned lunar samples, meteorites, and extraterrestrial dust grains. These continue to yield new information about the history of our solar system. This program is coordinated with the lunar sample and meteorite research, which is supported by other agencies, such as the National Science Foundation (NSF). The operation of the Lunar Curatorial Facility is also supported by this activity.

Instrument definition activities provide maximum scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation. The Mars Data Analysis program continues to support analysis of data obtained by Viking and earlier missions so that we are scientifically prepared for the next phase of Mars exploration. Establishment of a Planetary Data System (PDS) which will permit the archiving of these and all other data products in a manner promoting and facilitating their use, is also supported.

Advanced programs funding supports the planning and preparation of future planetary missions to ensure technical feasibility, scientific viability and consistency with the overall strategic planning and scientific objectives of the Planetary Exploration program.

Technology developed as part of the Search for Extraterrestrial Intelligence (SETI) program has been incorporated into the Towards Other Planetary Systems (TOPS) program and is funded within the R&A budget as the High Resolution Microwave Survey (HRMS). The program uses radio astronomy facilities and Deep Space Network (DSN) antennas to analyze microwave signals in space for technological evidence of intelligent life beyond our solar system.

Exobiology uses space and ground-based opportunities to study the cosmic evolution of biogenic compounds, prebiotic evolution, and the evolution of primitive and advanced life forms. The program examines these processes in the environments in which they occurred, including Earth, the planets of our solar system and elsewhere in the universe. Research is based on data from a wide variety of science disciplines such as planetary astronomy, geology, chemistry, and atmospheres. Additional areas of research include astrophysics, paleontology, and advanced development of flight experiments for Earth and planetary spacecraft. Theoretical models developed from analysis of existing data and laboratory investigations increase our understanding of early chemical and biological events that support the origin and evolution of life on Earth and elsewhere in the universe. This activity is transferred from Life Sciences beginning in FY 1994 to more accurately reflect the nature of the research conducted by the program.

CHANGES FROM FY 1993 BUDGET ESTIMATE

FY 1993 funding is reduced by $6.5 million due to a Congressionally-directed general reduction. Congress also directed the funding of the HRMS program ($12.0 million) and an increase of $5.0 million in Advanced programs for the NEAR and MESUR Pathfinder missions to be absorbed from existing R&A funds, which required a $23.5 million reduction to SR&T and Mars data analysis. The Agency's initial operating plan indicated

plans for use of $2.5 million from Advanced programs for acquisition of the Russian Mars '94 Lander engineering model to seek possible technology benefits for use in future NASA small missions. Plans for this activity are on hold pending further negotiation. These reductions are partially offset by a $1.3 million reallocation of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

During FY 1994, basic and applied research efforts will continue in all science disciplines. Funding will also support the upgrading of ground-based laboratories to reduce maintenance costs and improve capabilities. Instrument definition activities will continue to support development of new state-of-the-art instruments for future missions. Advanced programs support will continue to conduct future mission studies in support of the Discovery program as well as future Cassini-class missions to the outer solar system. The Mars Data Analysis program will support continued analysis of Mars data in preparation for new Mars missions, and development of the Planetary Data System to archive all planetary data for enhanced accessibility for all users will continue.

FY 1994 funds will continue to support the TOPS/HRMS program. Development of a Sky Survey operational system is underway with planned completion in 1996. Observations will continue in the interim via use of the prototype system fielded in FY 1993 at Arecibo, Puerto Rico and Goldstone, California. The Targeted Search system, currently operational, will be upgraded to full capability for its deployment to Australia in FY 1994.

The Exobiology program has also been transferred from Life Sciences to Planetary R&A beginning in FY 1994 to more accurately reflect the nature of the research conducted by the program. Research is directed toward understanding the origin and distribution of life, and life-related molecules on Earth and throughout the universe. The Exobiology program will emphasize the development of new flight experiment concepts which can validate theoretical models of solar system evolution and mechanisms for the synthesis of biologically significant molecules in space.

C-2.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Life sciences					
Research and analysis...............	50,700	55,600	53,940	49,200	RD 5-5
Flight experiments..................	94,700	89,700	81,089	94,700	RD 5-8
Centrifuge facility.................	(7,724)	18,400	5,521	--	RD 5-10
Search for extraterrestrial intelligence.....................	12,250	13,500	--	--	RD 5-13
Subtotal, life sciences...........	157,650	177,200	140,550	143,900	
Microgravity science research					
Research and analysis...............	(16,600)	(17,500)	(17,870)	18,400	RD 5-14
Flight experiments..................	(104,200)	(177,800)	(155,064)	71,000	RD 5-15
Shuttle/spacelab payload, mission management and integration..........	(78,000)	(101,100)	(94,018)	117,700	RD 5-17
Subtotal, transferred programs....	(198;800)	(296,400)	(266,952)	207,100	
Total..........................	157,650	177,200	140,550	351,000	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Johnson Space Center..................	63,500	68,457	59,500	118,884
Marshall Space Flight Center...........	--	--	--	89,360
Kennedy Space Center..................	5,700	6,342	4,900	24,758
Goddard Space Flight Center............	300	723	200	300
Jet Propulsion Laboratory..............	700	1,501	600	10,182
Ames Research Center..................	63,050	65,133	45,850	31,700
Langley Research Center................	800	1,112	600	2,200
Stennis Space Center..................	100	56	--	--
Lewis Research Center..................	200	--	100	36,800
Headquarters..........................	23,300	33,876	28,800	36,816
Total..........................	157,650	177,200	140,550	351,000

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS PROGRAM

OBJECTIVES AND JUSTIFICATION

Beginning in FY 1994, NASA's in-space research program for life science and microgravity research has been consolidated in order to best take advantage of flight opportunities available with the Shuttle/Spacelab program, as well as those presented through the international community. Toward this objective, all Shuttle/Spacelab science activities have been consolidated into the Life and Microgravity Science program. The elements included are the Life Sciences program, the Microgravity Research program, and the Shuttle/Spacelab Mission Management and Integration program. This consolidation was made to further optimize the joint science utilization of the Shuttle/Spacelab system, and with it, increase program synergy. This grouping will help focus attention on potential scientific, management, and programmatic overlaps in program objectives, and will streamline the utilization of the extensive Shuttle/Spacelab infrastructure.

The goal of the Life Sciences program is to conduct basic and applied biomedical and biological research which seeks to understand the role of gravity on living systems. Results from the research program are applied to maintaining astronaut health and productivity; understanding the response of biological mechanisms to weightlessness; study of basic cellular, developmental and physiological processes; and development of environmental health requirements and support systems for long-term piloted space flight. In FY 1993, the Life Sciences program is expanding its cooperation with the National Institutes of Health (NIH), with the objective of increasing participation of the mainstream biomedical community in the program. NIH Initiative activities include a wide range of ground-based and space flight research opportunities which span both the flight and the research and analysis programs.

The Life Sciences Flight Experiments program, consisting of Shuttle/Spacelab flight experiments program and other international cooperative efforts, selects, defines, develops, and conducts in-space medical and biological research. The flight experiments program is actively preparing experiments for launch on two Spacelab missions in 1993. Definition and development activities are underway to develop payloads for later Spacelab missions, including a joint program with Russia which is aimed at understanding biomedical problems associated with long-duration missions. As part of Shuttle/Spacelab experiments, the Extended Duration Orbiter Medical Program (EDOMP) is continuing its work to develop specific medical countermeasures for the extension of Shuttle flights to 16 days. The flight program involves important collaborative activities with other U.S. agencies, including the NIH and the National Science Foundation, and with the European Space Agency (ESA) and the space agencies of France, Germany, Japan and Russia.

The Life Sciences Research and Analysis program includes seven major elements: (1) Space Physiology & Countermeasures, (2) Human Factors, (3) Environmental Health, (4) Space Radiation Health, (5) Controlled Ecological Life Support Systems (CELSS), (6) Space Biology, and (7) Operational Medicine. The Research and Analysis program also includes the following additional activities: data archiving; NASA Specialized Centers of Research and Training (NSCORTs); NIH Initiative activities; and Cosmos/Mir cooperation.

Funding and management responsibility for the Search for Extraterrestrial Intelligence (SETI) program, previously budgeted within Life Sciences, has been deleted. Technology developed under this program has been incorporated in the Towards Other Planetary Systems (TOPS) program within the Planetary Exploration Research and Analysis program, in accordance with Congressional direction. In addition, the Exobiology program, previously budgeted within Life Sciences, has been transferred to Planetary Exploration to better reflect the nature of the research conducted in the program. No changes in program content or funding have been made.

The Microgravity Research program uses the unique attributes of the space environment to conduct research in three primary areas: 1) Fluid Physics, which includes the study of the behavior of fluids and transport phenomena, condensed matter physics, and combustion science; 2) Materials Science, which includes electronic and photonic materials, metals and alloys, glasses and ceramics; and 3) Biotechnology, which focuses on macromolecular crystal growth and mechanical environmental influence on cell science. Goals of the program include developing a comprehensive approach of basic and applied research in these primary areas. It is aimed at utilizing the low gravity environment to obtain new knowledge and understanding of those physical phenomena made obscure by the effects of gravity and to increase understanding of gravity-dependent phenomena. This understanding will add significantly to the basis of a reliable predictive capability for processing operations and technology issues in both Earth and non-Earth environments.

The Microgravity Research and Analysis program supports ground-based research and definition studies for flight experiment candidates in areas such as solidification and crystal growth, fluids and combustion research, gravitational physics, critical point phenomena and processing of biological materials. Ground-based research includes laboratories, drop-tubes, drop towers, and aircraft.

The Microgravity Research program provides a range of experimental capabilities. The program currently supports a wide variety of hardware development, such as unique flight experiments necessary to conduct benchmark research and modular, multi-user research facilities which will be the cornerstone of microgravity science and applications research in the future. Experiments will be principally flown on the Shuttle, Spacelab, and/or other commercially-developed spacecraft.

The Materials Processing in Space program has been renamed the Microgravity Science Research program in accordance with the 1992 National Research Council's recommendation.

BASIS OF FY 1994 FUNDING REQUIREMENT

LIFE SCIENCES RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Life sciences research and analysis........................	50,700	55,600	53,940	49,200

OBJECTIVES AND STATUS

The Research and Analysis activity supports Space Life Sciences program goals of advancing knowledge in all areas of space life sciences and developing medical and biological systems which enable human habitation in space. The objectives of the program are to support basic and applied studies which prepare for flight investigations on the Shuttle and Space Station; to use ground based models to simulate and study weightlessness and other aspects of space flight; to perform analysis of data from previous space flights; and to develop procedures and techniques in support of manned space flight, such as environmental standards and monitoring equipment. The program is composed of seven elements: (1) Space Physiology & Countermeasures, (2) Human Factors, (3) Environmental Health, (4) Radiation Health, (5) Controlled Ecological Life Support Systems (CELSS), (6) Space Biology, and (7) Operational Medicine. The research and analysis program also includes the following additional activities: Data Archiving; NASA Specialized Centers of Research and Training (NSCORTs); NIH Initiative activities; and Cosmos/Mir cooperation.

The Space Physiology and Countermeasures program focuses on the study of chronic physiological problems associated with extended duration in space, while the Human Factors program works on solutions to psycho-social challenges for crew members in isolated high-risk environments. The goal of the Environmental Health program is to assess environmental risk by developing a toxicology database and contamination modeling capacity, determining spacecraft maximum allowable concentration limits, and developing new technologies for environmental monitoring. The Radiation Health program is working towards establishing the scientific basis for the radiation protection of humans engaged in space. The CELSS program seeks to provide air, water, and food to support life through a combined physical-chemical-bioregenerative closed system which could receive only energy from the external environment. The Space Biology program explores the role of gravity in life processes and uses gravity variations as an environmental tool to investigate fundamental biological questions. The Operational Medicine program provides medical support to all manned missions and explores the role of gravity in life processes and uses gravity variations as an environmental tool to investigations, develops an estimate of medical risks associated with advanced missions with humans, and establishes biomedical countermeasures and life support research priorities.

Exobiology research is directed toward understanding the origin and distribution of life, and life-related molecules, on Earth and throughout the universe. Beginning in FY 1994, this program will be transferred to Planetary Exploration Research and Analysis, in order to more accurately reflect the nature of the program's research activities.

Data archiving activities strive to develop an operational database for archiving results of the NASA Life Sciences Research program for dissemination in a readily accessible form to the life sciences community nationwide and, eventually, internationally. The NIH Initiative activities within the research and analysis program supports grants to individual researchers and research teams as well as data archiving and secondary data analysis activities. Cooperation with the NIH will also lead to the development of new NASA Specialized Centers of Research and Training (e.g. with the National Institute on Deafness and Other Communication Disorders), the development of a new program of NASA supplements to ongoing NIH grants, and joint activities with the National Library of Medicine concerning bibliographic databases and flight data archiving.

The NSCORT program serves to advance basic knowledge and generate effective strategies for solving problems in focused research areas. In FY 1993, the sixth and seventh NSCORT will be established, one for integrated physiology and the other, in cooperation with the NIH, for vestibular research. Overall, the Life Sciences NSCORTs will conduct research in the following science programs: space biology, environmental health, space radiation health, controlled ecological life support systems, integrated physiology and vestibular research. Ultimately, the life sciences NSCORT program will expand to a total of nine participating institutions.

Research activities on Mir study the effects of long duration space flight on Cosmonauts by doing pre-flight and post-flight biomedical evaluations (e.g. bone densiometry). Activities associated with the FY 1993 Cosmos biosatellite include experiment development, support of flight activities, and post-flight data analysis.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Overall funding for the Research and Analysis program has been decreased by $1.7 million. This reflects the Congressionally-directed reduction of $4.0 million; an additional $2.2 million reduction as part of the directed $20.0 million life sciences general reduction; the transfer of the $1.6 million biospheric research program to Space Applications (Earth Science Research and Analysis) to consolidate funding and program management responsibility; and the addition of $5.2 million for NIH cooperative activities. These program adjustments are partially offset by a $0.9 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Basic research activities will continue to use Earth-based models to simulate the effects of weightlessness and other components of the space flight environment, and provide for extended data analysis and supporting studies so that investigators can learn as much as possible from data collected in space. These studies will further refine our understanding of how microgravity can be used to investigate questions of medical and basic biological importance on Earth such as blood pressure control, maintenance of bone and muscle mass, vestibular function and the regulation of balance, cell metabolism and division, etc.

The Environmental Health program will develop and refine environmental standards in areas such as microbiology and toxicology; these standards will be key to developing safe and cost-effective life support and environmental monitoring systems. The Radiation Health program will continue to operationally monitor radiation exposure of Shuttle crews, refine dose estimates and study the biological effects (especially the increased risk of cancer) of space radiation exposure. Further, the Space Human Factors program will use remote, harsh and isolated environments such as the polar regions to develop standards for psychological selection, test and develop new training procedures, and design new systems that use state-of-the-art knowledge of human operations with complex automated systems.

The CELSS program will continue to investigate biological and physical-chemical methods to control the interior environment of piloted spacecraft. In addition to ongoing research in biomass production and waste management systems, near-term emphasis will be on development of laboratory scale models and definition of man-rated systems for proof of design concepts.

The Research and Analysis programs will continue to develop joint activities with the NIH, as discussed in a following separate section.

BASIS OF FY 1994 FUNDING REQUIREMENT

LIFE SCIENCES FLIGHT EXPERIMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Flight experiments....................	94,700	89,700	81,089	94,700

OBJECTIVES AND STATUS:

The objective of the Life Sciences Flight Experiments program is to develop and utilize payloads designed to expand the understanding of the basic physiological mechanisms involved in adaptation to the space environment. The program includes selection, definition, in-flight operation, data analysis and reporting on medical and biological investigations involving humans, animals, and plants. The program's flight experiments lead to a better understanding of gravitational adaptation, enhance our basic science knowledge and increase the confidence with which we can estimate the physiological consequences of longer exposure to the space environment.

In FY 1993, preparations in the Shuttle/Spacelab Flight Experiments program are underway to support several Shuttle/Spacelab missions. Among these are the SL-D2 cooperative mission with Germany and the second dedicated life sciences mission, Spacelab Life Sciences-2 (SLS-2). The Spacelab-D2 life sciences experiments will focus on cardiovascular physiology and fluids systems. The SLS-2 experiments will focus on cardiovascular, metabolic, musculoskeletal and neurovestibular functions and gather additional data for the Extended Duration Orbiter Medical Program (EDOMP). As part of the Flight Experiments program, EDOMP is continuing its work to develop specific medical countermeasures for the extension of Shuttle flights to 16 days. In FY 1993, nine animal and plant experiments will also be flown as Shuttle secondary payloads.

Efforts in the Flight Experiments program also continue on definition and development of new experiments and hardware planned to be flown on the third and fourth dedicated life sciences missions (SLS-3 and -4), the 1995 cooperative Mir mission with Russia and in future orbiter middeck areas. SLS-4 participation will be dedicated to brain and behavioral research, and will be the first Spacelab with major NIH involvement, serving as the main NASA contribution to the Decade of the Brain. The cooperative mission series with Russia will involve three elements: a Shuttle mission on which a Cosmonaut is a crew member (STS-60); a mission on which one astronaut will stay aboard the Russian Mir Space Station; and a Shuttle docking mission of the Shuttle/Spacelab with the Mir. This program will provide the opportunity for both countries to understand each other's methods and approaches to long-term human physiologic adaptation to space flight, as

well as provide the U.S. with its first long-duration mission information since the Skylab program. Continuation of previous NASA collaboration with the former Soviet Union in its COSMOS biosatellite program is planned, with joint research on one COSMOS flight in FY 1993.

CHANGES FROM FY 1993 BUDGET ESTIMATE

An overall reduction of $10.6 million in the Flight Experiments program is the result of several actions. A $21.7 million reduction has been applied to the ongoing Flight Experiments program as a result of FY 1993 appropriations action. Partially offsetting this reduction are program additions of $2.0 million to fund requirements for the 1995 Shuttle-Mir rendezvous mission; $4.8 million for cooperative activities with NIH as directed by Congress, (the remaining $5.2 million of NIH funding is included within the Research and Analysis program); and $6.3 million due to the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

During FY 1994, specific studies within the Life Science Flight Experiment program will focus on the feasibility of extending crew stay times aboard the Space Shuttle. Key activities include the requirements and technology development for operational medicine, radiation protection and environmental health; countermeasure development and testing; human factors engineering; and life support systems testing and monitoring. Cooperation with the NIH will result in secondary payload flight opportunities in FY 1994 focused on developmental biology, cell biology and physiology. As in the past, continued medical support and monitoring of crew health will be provided for each of the Space Shuttle missions flown in FY 1994.

Towards these objectives, a major activity in FY 1994 will involve preparations for the three-mission series of U.S./Russia cooperative research. Post-flight analysis of the data received from experiments aboard STS-60, the initial segment of the cooperative program, will continue. Hardware development, testing, integration and delivery of experiments and equipment planned for flight aboard the Mir and the Shuttle for the Mir docking mission will continue toward their 1995 flights. Astronaut and cosmonaut crew training is under way at both the Russian and Johnson Space Center sites. Experiment integration for the docking mission will begin in late summer, 1994.

Preparations will continue in support of the 1994 IML-2 Spacelab mission, with experiments being completed and readied for integration. Significant analysis will continue on the results of the late FY 1993 SLS-2 mission. Funds are also included in support of the continuing cooperative relationship with NIH, discussed in a following, separate section.

Funds are not included in the FY 1994 estimate for Space Station and related activities. The requirements definition, design and development of hardware and experiments for the Space Station are being reevaluated consistent with the Agency's reexamination of its plans for development of the Space Station. A revised program plan consistent with the redesign proposal selected will be submitted to the Congress at a later date.

BASIS OF FY 1994 FUNDING REQUIREMENT

CENTRIFUGE FACILITY

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Centrifuge facility....................	(7,724)	18,400	5,521	--

OBJECTIVES AND STATUS

The Centrifuge Facility is designed to conduct on-orbit operations of a 0 to 2g specimen support capability for long-term research on Space Station Freedom (SSF). The Centrifuge Facility will accommodate the requirements of a wide variety of biological investigations using animals, plants, cells and tissue cultures, and will improve understanding of gravity's role in living organisms' functions and development. This facility represents a marked enhancement of basic research capability to the Life Sciences program, and has been a top priority recommendation of the National Academy of Sciences for several years. Development of the facility was planned to begin in FY 1993, with contract award expected in the third quarter.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding for the Centrifuge facility has been reduced by $12.9 million. This change reflects the reduction of $10 million specifically directed by Congress and an additional $3.1 million as part of a Life Sciences general reduction directed by Congress. These adjustments are offset by a $0.2 million increase due to the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

No funds have been included in the FY 1994 request for the currently-planned Centrifuge Facility. The funding plans are being reevaluated consistent with the Agency's reexamination of its plans for the Space Station. A request for funds to continue development of the centrifuge will be deferred subject to the Space Station redesign plans and revised schedule.

BASIS OF FY 1994 FUNDING REQUIREMENT

NATIONAL INSTITUTES OF HEALTH INITIATIVE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research & analysis	--	--	(5,200)	(5,200)
Flight program	--	--	(4,800)	(4,800)
Total	--	--	(10,000)	(10,000)

OBJECTIVES AND STATUS

The objective of the NASA/National Institutes of Health (NIH) Initiative is to expand participation of the mainstream biomedical community in the NASA Life Sciences program. The most effective way to expand this participation is to collaborate with and through the NIH. The joint research programs will seek to involve the best researchers and institutions in space life sciences research opportunities by providing supplements to ongoing NIH grants, funding of joint research centers at universities and medical schools, and soliciting and funding new individual grants. Cooperation with the NIH will also lead to the development of new NASA Specialized Centers of Research and Training (NSCORTs), the development of a new program of NASA supplements to ongoing NIH grants, NIH use of unique NASA facilities, (e.g. the Vestibular Research Facility and Biocomputation Center at Ames Research Center), as well as joint activities with the National Library of Medicine concerning bibliographic databases and flight data archiving. NASA will have the lead in joint space flight research activities; NIH will lead in joint ground-based research activities.

The scope of joint flight activities include Shuttle middeck locker flight opportunities beginning in late FY 1993 (e.g. Physiological and Anatomical Rodent Experiments (PARE)) and additional opportunities on future missions such as those utilizing the Spacelab, and potentially, non-U.S. space platforms such as Mir and Biocosmos. The SLS-4 participation will be dedicated to brain and behavioral research, and will be the first Spacelab with major NIH involvement, including funding for investigators. In addition, SLS-4, planned for a 1998 flight, will be the main NASA contribution to the Decade of the Brain.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The NIH Initiative funding of $10.0 million has been applied to both the Flight Experiments program ($4.8 million) and the Research and Analysis program ($5.2 million).

BASIS OF FY 1994 ESTIMATE

Cooperation with the NIH will result in secondary payload flight opportunities in FY 1994 focused on developmental biology, cell biology and physiology. Within the Research and Analysis program, joint activities will continue to be developed so that U.S. capabilities can be most efficiently used to maintain the health of people on Earth and in space, and will include supplements to ongoing NIH grants, funding of joint research centers, and soliciting and funding new individual grants.

BASIS OF FY 1994 FUNDING REQUIREMENT

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Search for extraterrestrial intelligence......................	12,250	13,500	--	--

OBJECTIVES AND STATUS

The Search for Extraterrestrial Intelligence (SETI) program has been deleted from the Space Life Science program. Technology developed under this program has been incorporated in the Towards Other Planetary Systems (TOPS) program in the Planetary Exploration Research and Analysis program, in accordance with Congressional direction.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Per Congressional direction, funding has been terminated for SETI within the Life Sciences program.

BASIS OF FY 1994 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research and analysis..................	(16,600)	(17,500)	(17,870)	18,400

OBJECTIVES AND STATUS

The research and analysis activity provides the scientific foundation for all current and future projects. Ground-based research leads to space investigations with potential for future applications. This activity also provides analytical support and technology development for future ground and space capabilities. Most research projects are a result of proposals from the scientific community stemming from NASA research announcements, and are extensively reviewed by peer groups prior to selection and funding.

CHANGES FROM FY 1993 BUDGET ESTIMATE

FY 1993 funding is increased by $0.4 million due to the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

Ground-based research and analysis will continue in FY 1994 in the areas of benchmark science, materials science, and biotechnology. Research objectives include definition of the role of gravity-driven influences in a variety of processes. A series of solicitations (NASA Research Announcements and Announcements of Opportunity) will be released to focus and expand the science community involvement. This will allow for the development of strong candidates for future flight opportunities.

BASIS OF FY 1994 FUNDING REQUIREMENT

MICROGRAVITY SCIENCE FLIGHT EXPERIMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Flight experiments....................	(104,200)	(177,800)	(155,064)	71,000

OBJECTIVES AND STATUS

During FY 1992 the first United States Microgravity Laboratory (USML-1), the first United States Microgravity Payload (USMP-1), the first International Microgravity Laboratory (IML-1), and Spacelab-Japan all flew with outstanding experimental results.

The Flight Experiments program provides hardware for experiments for a wide range of opportunities. NASA currently supports the development of Shuttle middeck, Spacelab, and cargo-bay experiments. This policy maximizes the effective use of the Shuttle by developing hardware to meet scientific and technical requirements. Long-term program plans assume the availability of a Space Station or other long-term platform as a major element for conducting microgravity research, consistent with the strategy for evolution of microgravity experiments from short to long duration periods of on-orbit operations. Current activities also include participation in the joint U.S.-Russian Spacelab-Mir mission. Several experiments are in preparation.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The program has been reduced by a total of $22.7 million. In accordance with Congressional direction, a $25.0 million reduction has been accommodated by deferring development of hardware and experiments for the Space Station. These adjustments are offset by a $2.3 million increase due to the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funds are required to continue basic and applied research activities as well as payload development for use in the Space Transportation System (STS) middeck, Spacelab, and Shuttle cargo bay for future flights of the USML and USMP series, as well as IML-2. Investigations are planned in electronic materials, metals and alloys, glasses and ceramics, biotechnology, combustion, fluid physics and dynamics. The future flight rates of these Spacelab missions remain largely dependent upon the Agency's plans for a future Space Station, currently under review.

FY 1994 begins the development of new equipment for the Shuttle middeck and other planned Spacelab missions. This new equipment will be used to carry out scientific investigations chosen from NASA Research Announcements in Combustion Science, Material Science, Biotechnology, Fluid Physics, and Fundamental Science. These investigations represent the future of the microgravity science program, as the results of USML-1, IML-1, and USMP-1 are disseminated and the program readies investigations for later Shuttle missions. Activities will continue in FY 1994 on the cooperative U.S./Russia Spacelab-Mir mission, scheduled for a 1995 launch. Funding will support the modification of several hardware items planned for flight aboard Mir, including the Advanced Protein Crystal Growth facility and the Space Acceleration Measurement System.

No funds are being requested at this time for Space Station hardware and related research. Requirements definition, design and development of hardware and experiments for the Space Station are being reevaluated consistent with the Agency's reexamination of its plans for development of the Space Station. A request for an appropriate level of funding in relation to the outcome of the redesign process will be submitted upon completion of that process.

BASIS OF FY 1994 FUNDING REQUIREMENT

SHUTTLE/SPACELAB PAYLOAD MISSION MANAGEMENT AND INTEGRATION

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Shuttle/Spacelab payload mission management and integration..........	(78,000)	(101,100)	(94,018)	117,700

OBJECTIVES AND STATUS

The primary objective of the Spacelab Payload Mission Management program is to manage the mission planning, integration, and execution of all NASA Spacelab and attached Shuttle payloads. This includes system management and engineering development of flight support equipment and software; development of certain interface hardware; payload specialist training and support; integration of the science payloads with the Spacelab system; payload flight operations; and data dissemination to experimenters.

Mission management activities are ongoing for several upcoming missions, such as the Atmospheric Laboratory for Applications and Science (ATLAS). The second of this series is planned for flight in FY 1993, with the third scheduled for 1994. The mission will incorporate a large number of instruments designed to support NASA's Mission to Planet Earth program of research. Other missions include flights of an imaging radar (SRL) beginning in FY 1994; a series of Spacelab Life Sciences (SLS) missions; the second flight of a cooperative International Microgravity Laboratory (IML-2); a series of U.S. Microgravity Payloads (USMP's), U.S. Microgravity Laboratories (USML's), and Microgravity Science Laboratories (MSL's); and a reflight of the Astro Spacelab mission (Astro-2) in 1994. Mission management activities also support other NASA payloads, for example, the Lidar In-space Technology Experiment (LITE), a 1994 launch, which will demonstrate technology and measurement techniques with high potential for use in studies of the Earth's atmosphere. Several Shuttle middeck experiments are also supported.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The net reduction of $7.1 million in FY 1993 reflects several actions. The following reductions were made: a $5.0 million reduction directed by Congress; a reallocation of $9.0 million to NASA's Academic programs to partially offset the impact of Congressional mandates; and a reallocation of $2.0 million to Life Sciences

to support the joint NASA/Mir mission These reductions were made possible due to extensive Shuttle manifest changes and the termination of the Canadian Waves in Space Plasma (WISP) mission. The reductions are partially offset by the transfer of $3.0 million from Physics and Astronomy/Payload and Instrument Development to provide Spacelab support for the Astro-2 mission; an increase of $0.9 million due to the redistribution of ROS funding; and an increase of $5.1 million in order to support the flight of the Atlas-3 Spacelab mission in 1994.

BASIS OF FY 1994 ESTIMATE

Mission management activities will continue in FY 1994 with several Spacelab missions planned this fiscal year. Integration, testing, analysis and evaluation will continue for these major Shuttle/Spacelab missions including the IML-2, the first flight of the SRL-1, and the Atlas-3. Preparation for FY 1995 and subsequent missions will continue, including a significant effort devoted towards the cooperative Spacelab mission and rendezvous with the Russian MIR space station, scheduled for mid-1995.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Earth observing system	176,400	308,400	263,784	322,700	RD 6-7
Earth observing system data information system	77,670	82,600	130,651	182,700	RD 6-11
Earth probes	77,800	88,900	99,413	97,300	RD 6-13
Advanced communications technology satellite	18,700	3,600	3,968	3,000	RD 6-15
Ocean topography experiment	65,000	--	--	--	
Payload and instrument development	37,900	49,400	35,461	22,900	RD 6-16
Mission operations and data analysis	100,646	142,100	147,553	160,800	RD 6-19
Interdisciplinary research	2,340	2,600	4,453	5,000	RD 6-23
Modeling and data analysis	45,798	45,000	42,571	45,000	RD 6-24
Process studies	121,539	126,600	119,255	131,500	RD 6-27
Airborne science and applications	20,300	22,900	20,707	25,200	RD 6-30
Mission to planet earth information systems	--	--	--	11,800	RD 6-32
Research operations support	83,909	98,000	70,061	67,000	RD 6-34
Subtotal, mission to planet earth	828,002	970,100	937,877	1,074,900	
Information systems	35,000	40,700	36,193	(26,500)	RD 3-32 RD 6-32
Material processing in space, research and analysis	16,600	17,500	17,870	(18,400)	RD 5-14
Material processing in space, flight experiments	104,200	177,800	155,064	(71,000)	RD 5-15
Search and rescue	1,300	1,000	1,018	(1,100)	RD 8-16
Subtotal, transferred programs	157,100	237,000	210,145	(117,000)	
Total	985,102	1,207,100	1,148,022	1,074,900	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF MISSION TO PLANET EARTH

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Johnson Space Center....................	2,800	3,843	7,700	--
Kennedy Space Center....................	185	--	219	254
Marshall Space Flight Center...........	49,196	82,685	68,164	15,672
Stennis Space Center....................	369	853	436	508
Goddard Space Flight Center............	461,835	507,251	529,711	581,384
Jet Propulsion Laboratory..............	158,550	290,066	183,289	182,805
Ames Research Center....................	35,909	59,997	42,987	38,932
Lewis Research Center..................	63,619	69,736	67,793	1,864
Langley Research Center................	30,418	43,062	37,904	37,707
Headquarters...........................	182,221	149,607	209,819	215,774
Total............................	985,102	1,207,100	1,148,022	1,074,900

OFFICE OF MISSION TO PLANET EARTH

OBJECTIVES AND JUSTIFICATION

The ongoing Mission to Planet Earth program is making critical near-term contributions to understanding the Earth as an integrated system as well as to environmental issues, including global warming and ozone depletion. NASA's base program combines ground-based measurements, laboratory studies, data analysis and model development with a progressive series of satellite missions, supporting cloud climatology, Earth radiation budget, ozone monitoring, atmospheric chemistry, and ocean circulation. The NASA program also supports a broad interdisciplinary, basic research program.

The ability to measure the extent of both the natural and man-induced changes in our global ecosystem is only a preliminary step - the capability to model and to predict the consequences of global change is the ultimate objective. The U.S. Global Change Research Program (USGCRP), in which NASA has been a major participant, provides a focused and effective mechanism for coordinating and directing federally-funded Global Change research.

The specific objectives of the NASA Mission to Planet Earth program are to improve our understanding of the processes in the atmosphere, oceans, land surface and interior of the Earth, and to advance our knowledge of the interactions between these environments. The program provides space observations of parameters involved in these processes and extends the national capability to predict environmental phenomena, both short- and long-term, and their interactions with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes only, observed from space. NASA's programs include scientific research efforts as well as the development of new technology for global and synoptic measurements. NASA's research satellite, Shuttle/Spacelab payload, and airborne science and applications programs provide a unique view of the planet Earth, its physical dynamics, and radiant energy and chemical processes that affect habitability and the solar-terrestrial environment.

NASA has established several significant objectives in the Mission to Planet Earth program for the next decade. Missions and research will emphasize advancement of our understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and the sources in the lower atmosphere. NASA will characterize the current state of the terrestrial landscape, including the biosphere and the hydrosphere.

Investigators will use space-derived measurements to increase understanding of large-scale weather patterns. Researchers will increase capabilities for severe storm forecasting as well as knowledge of ocean productivity, circulation, and air-sea interactions. A long-term strategy for climate observation and prediction will improve knowledge of seasonal climate variability. Understanding the cycling of key biogeochemical elements, interactions between the biosphere and the climate system, the composition and evolution of the crust and the processes that shape the crust are essential to our understanding of the global environment.

The primary objective of the Earth Observing System (EOS) is to document global climate change and to observe regional-to-global scale processes. Utilizing several satellites, EOS will document global climate change over a fifteen-year period to provide long-term, consistent data sets for use in modeling and understanding global processes. This process and modeling research effort will provide the basis for establishing predictive global change models for policy makers' and scientists' use in formulating strategies to manage human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation.

The Earth Probes program provides small, specialized satellites and instruments for non-NASA satellites to complement data gathered by EOS. These satellites require special orbits and spacecraft capabilities and will provide data on tropical rainfall (Tropical Rainfall Measurement Mission (TRMM)), ocean wind speed and direction (NASA Scatterometer), and global ozone concentrations (Total Ozone Mapping Spectrometer (TOMS)). These missions are necessary for a complete understanding of the global climate systems.

The Advanced Communications Technology Satellite (ACTS) mission will be launched in 1993. The program will maintain United States leadership in the communications satellite market through the development and flight verification of advanced technologies that enhance the capability of communications satellites.

Launch of the Ocean Topography Experiment (TOPEX/Poseidon) occurred in August 1992. The launch and antenna deployments were successful and the satellite is operating normally. The objective of TOPEX/Poseidon is to acquire precise observations of the surface topography of the ocean. These data, in conjunction with the Scatterometer data, will enable the first determination of the wind forcing and ocean current response of the global oceans.

The objectives of the Payload and Instrument Development program are to develop, test, and evaluate Earth-viewing, remote sensing instruments and systems. Experimenters will obtain data necessary for basic research projects as well as provide correlative and developmental feasibility information for major free-flying spacecraft. Current instrument developments include the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS); Active Cavity Radar (ACR); Light Intersection Direction and Ranging (LIDAR); Measurement of Air Pollution from Satellites (MAPS); and the Shuttle Imaging Radar-C (SIR-C).

The Mission Operations and Data Analysis program actively collects data from operating Mission to Planet Earth missions. The Upper Atmospheric Research Satellite (UARS) and TOPEX/Poseidon missions are the most recent launches. NASA will obtain ocean color data for research use from the Sea-viewing Wide Field Sensor (SeaWiFS) instrument, planned for launch on SeaStar in 1994. The long-term ocean color data sets will contain data related to the biological productivity and ecology of oceans, seas, and larger lakes. The Nimbus spacecraft continues to collect unique data for the study of long-term trends of the Earth's atmosphere, oceans, and polar ice. The Earth Radiation Budget Experiment (ERBE), launched in 1984, continues to provide valuable data on total solar irradiance and its temporal variations.

The Interdisciplinary Research program will continue integrating discipline-specific research activities into a unified program that will help increase our understanding of critical global processes. Specific pilot studies are conducted, such as those concerning processes controlling atmospheric methane concentrations, changes in land surface properties and their effect on climate, and the role of oceans in the global carbon cycle.

The Modeling and Data Analysis program focuses on developing predictive models for global change and analyzing data sets to determine mechanisms at work in the global environment. The program emphasizes two major areas - physical climate and hydrological systems, and biogeochemistry and geophysics. Specifically, research will stress the development of coupled global atmosphere-ocean models to diagnose the present climate, to assess impact to the climate of increases in atmospheric trace gases such as carbon dioxide, and in experimental forecasting of climate on the inter-annual to decadal time scale. Researchers will work to improve techniques for assimilation of satellite data for model initialization and validation.

The Process Studies program will utilize a variety of techniques to develop an understanding of the processes at work in the global environment and to determine interdependencies that may impact global change management strategies. The program will utilize existing data sets and will conduct field experiments that will enable researchers to understand global environmental dynamics. Process studies concentrate on four major interdisciplinary categories - radiation dynamics and hydrology; ecosystem dynamics and biogeochemical cycles; atmospheric chemistry; and solid Earth science, including operation of the laser research facilities.

The Airborne Science and Applications program continues to provide aircraft-based platforms for observing and investigating mechanisms in ozone-depleting reactions in the atmosphere over the Arctic and Antarctic. The Airborne program also provides a variety of platforms for diverse studies in oceanography, terrestrial ecology, hydrology, soil studies, tropospheric chemistry, and geology. In addition, the FY 1993 program will focus on a number of international campaigns in Australia (Tropical Oceans Global Atmosphere Program (TOGA)) using the ER-2 and DC-8 aircraft, and Australia and South America for SIR-C precursor studies using the DC-8/AIRSAR (Airborne SAR) system. NASA canceled a planned FY 1993 volcanology study to Kamchatka, Russia, due to Congressional budget reductions that resulted in grounding of the C-130 aircraft in FY 1993.

The Mission to Planet Earth information system activity will continue supercomputing at the Goddard Space Flight Center (GSFC) and the Jet Propulsion Laboratory (JPL), including enhancements to keep pace with requirements.

The Research Operations Support (ROS) provides vital support to the civil service workforce and to the physical plant at the GSFC and at NASA Headquarters. Funding to support activities which directly benefit the NASA programs are included in the program budgets.

In FY 1994, NASA reorganized the Space Applications budget to include only Mission to Planet Earth activities. The Material Processing in Space Flight experiments and Research and Analysis budgets have been transferred to the Life and Microgravity Sciences and Applications program. The Information Systems program has been divided between the Space Science program and the Mission to Planet Earth program. The Search and Rescue activity has been transferred to the Commercial Use of Space program.

BASIS OF FY 1994 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Instruments	114,000	--	--	--
Observatories	31,000	--	--	--
Science*	31,400	18,000	44,996	47,100
AM series	--	241,500	181,388	200,100
PM series	--	30,900	24,100	58,200
Chemistry	--	6,800	1,100	1,500
Special spacecraft	--	11,200	12,200	15,800
Total	176,400	308,400	263,784	322,700
Launch vehicles	--	(2,900)	(2,800)	(20,100)

* The FY 1993 Budget Estimate included interdisciplinary science only. The FY 1993 Current Estimate includes all EOS science.

OBJECTIVES AND STATUS

The objective of the Earth Observing System (EOS) is to acquire a long-term set of comprehensive measurements of various aspects of the Earth system. The EOS program will provide the basis for predictive global climate change models for policy makers' and scientists' use in formulating strategies to mitigate human impacts on global processes such as the greenhouse effect, ozone depletion, and deforestation. The EOS program fulfills the science requirements of the Intergovernmental Panel on Climate Change (IPCC).

The EOS program will provide comprehensive measurements of parameters affecting global climate change. The program includes three U.S. flight series: the AM, PM, and Chemistry. The special spacecraft include the Altimetry and Aerosol series, which will depend on international participation, and the possible flights of some instruments on Japanese, European, and other international spacecraft. EOS also includes an ocean color data purchase. The science budget supports interpretation of the collected data. The AM, PM, and Chemistry flight series will be designed to last five years, flying three times, making measurements over fifteen-year periods. The AM series science objectives are to measure physical and radiative properties of

clouds; air-land exchanges of energy, carbon, and water; and vertical profiles of carbon monoxide and methane. The PM series will study cloud formation, precipitation, and radiative properties; air-sea fluxes of energy and moisture; and sea-ice extent and heat exchange with the atmosphere. The remaining EOS missions will examine aerosol and chemical properties of the troposphere and stratosphere, ocean altimetry and circulation, and ice sheet mass balance.

The EOS missions will monitor many parameters that are indicators of the state of the environment, such as the spatial and temporal distribution of tropospheric and lower stratospheric gases. In addition, interdisciplinary theoretical investigations will utilize EOS data sets and complementary data sets to study such phenomena as ecosystem distributions and conditions; biogeochemical fluxes at the ocean-atmosphere and land-atmosphere interfaces; the global carbon cycle; and atmospheric composition.

During 1992, the EOS program was significantly replanned in response to the constrained agency budgetary environment. While reducing the overall cost of the mission, NASA maintained the ability to meet the science objectives of the IPCC. The result is a program essentially similar to the restructured program submitted in the FY 1993 budget, with the incorporation of a number of cost-saving process improvements: implementing a common spacecraft approach for the follow-on U.S. series; adopting a build-to-cost approach for the first unit of a multiple instrument build; and increasing reliance on the cooperation of international and other U.S. partners. NASA deleted from the program the High Resolution Imaging Spectrometer (HIRIS) instrument, the highest technical development risk instrument, assuming that a continuing Landsat program will meet many of the HIRIS science objectives.

Taking maximum advantage of work already in process, the AM-1 spacecraft will be unique, to support the unique instrument combination planned for the first EOS flight. The follow-on flight series are being designed to use a common spacecraft. The AM series, with a morning equatorial crossing, the PM series, with an afternoon equatorial crossing, and the Chemistry series will fly as intermediate-size spacecraft. The other missions are small-class spacecraft, taking full advantage of international cooperation.

Concurrent with the replanning exercise, work has continued in unaffected areas: the AM-1 spacecraft began the subsystem Preliminary Design Review (PDR) cycle, and the AM-1 instruments continued to progress through the preliminary design stage. The Clouds and Earth's Radiant Energy System (CERES) instrument completed a successful PDR, and the Canadian Space Agency selected the development contractor for Measurement of Pollution in the Troposphere (MOPITT), the last AM-1 instrument to enter the full-scale development phase. NASA has issued directions to implement the replanning/rescoping exercise changes. Definition-phase contracts were awarded for the common spacecraft buy for the follow-on flights.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The changes in the FY 1993 budget estimates are a result of a realignment within the total EOS program. The increase in the Science budget is due to the reallocation of mission science tasks associated with the individual flight series to the Science program. In addition, funding for science computing facilities and science data product capability development previously included in the individual EOS missions have been transferred to the EOS Data and Information System (EOSDIS) budget. These adjustments include a $2.3 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

During FY 1994, all aspects of the AM-1 flight development will be fully under way. NASA will complete Critical Design Reviews (CDR's) for the AM-1 instruments - Clouds and the Earth's Radiant Energy System (CERES), Moderate-Resolution Imaging Spectrometer (MODIS), Multi-Angle Imaging Spectro-Radiometer (MISR), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and Measurements of Pollution in the Troposphere (MOPITT). Japan and Canada are developing the ASTER and MOPITT instruments, respectively. In support of these CDR's, the instrument developers will build engineering models for test and evaluation by the end of FY 1994. The three U.S.-made instruments will begin fabrication of the protoflight units in 1994. The spacecraft subsystem (e.g. structures, thermal control, command and data handling, etc.) CDR's for the AM-1 spacecraft will also be conducted in FY 1994, in preparation for the spacecraft system level CDR in FY 1995 leading to flight in 1998. The last of the spacecraft subsystem components (e.g., star trackers, solar array, etc.) will have been awarded to subcontractors by early 1994. With the successful completion of these CDR's, drawings will have been released and manufacturing organizations will fabricate the space flight hardware.

Preliminary design activities will continue on the instruments planned for the PM-1 flight. Of particular importance is the need to maintain progress on the development of the Atmospheric Infrared Sounder (AIRS), an effort which is technologically demanding and has been under way since the initial selection of AIRS for EOS-A1 in FY 1991. Of the other instruments planned for PM-1, two are copies of instruments already being built for AM-1; these instruments will have a compressed design schedule with both PDR and CDR occurring during 1994. The remaining instruments, which include two supplied by the international community, will be in the preliminary design phase, which includes the initiation of engineering model builds and long-lead parts buys. Results of the definition studies for the follow-on EOS spacecraft (AM-2,-3; PM-1,-2,-3; CHEM-1,-2,-3) will be incorporated into a request for proposal, which is planned for release to industry in early FY 1994. Proposals for the spacecraft development contract will be evaluated and a selection made in 1994. This will lead to initiation of full-scale-development of the PM-1 flight in 1995, for a launch in calendar year 2000.

The procurement process associated with the ocean color data purchase will be initiated in 1994 to ensure data coverage after 1998.

In FY 1994, the EOS science principal investigators and science facility teams continue development of the EOS science and analysis algorithms. They also continue to support the EOSDIS development by defining science requirements of the EOSDIS Core System algorithm development tool kits due at the end of calendar year 1994. Phased deliveries of the tool kits throughout 1994 will lead to the preliminary science software for AM-1 in 1995. The science software deliveries are critical items toward achieving the final data products from the science instruments.

BASIS OF FY 1994 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Earth observing system data information system.................	77,670	82,600	130,651	182,700

OBJECTIVES AND STATUS

A key element enabling EOS to meet the program's long-term science goals, and those of Mission to Planet Earth, is the Data and Information System (EOSDIS). The EOSDIS will provide the processing, storage, and distribution of the EOS science data and the resulting scientific products. The EOSDIS system will also have the capability for spacecraft and instrument command and control. Additionally, EOSDIS will provide data archive and distribution and information management for all NASA Mission to Planet Earth data.

The EOSDIS will be evolutionary, with capability phased to support the requirements of the rescoped EOS program and those of other Mission to Planet Earth spacecraft and data sources. The Distributed Active Archive Centers (DAAC's) will perform continuous processing of instrument data to derive the underlying scientific parameters of interest. The network will link the archived data and products so that investigators may access the entire set of holdings from any entry point. An information management service will help users locate data within the total archive. The network also will interface with international partner instruments and control facilities and will provide operational data to agencies such as the National Oceanic and Atmospheric Administration (NOAA).

The EOSDIS includes the development of operational ground systems for spacecraft and instrument command and control, the EOS Data Operations System (EDOS) and the EOS Communications System (ECOM). These systems accept data from the Tracking and Data Relay Satellite System (TDRSS) ground terminal, process it, and deliver data products to the scientists through the EOSDIS. The EOSDIS also provides for the Independent Verification & Validation (IV & V) of the EOSDIS core system.

In 1992, the EOS program was significantly replanned in response to the constrained agency budget environment. The replanning affected EOSDIS by limiting the data products available at time of launch to those of only the highest scientific priority and by planning for early transition of the DAAC focus from

Version 0 development to engineering of the Version 1 operational DAAC's. NASA deferred transfer of data sets from pre-existing systems where they are independently accessible. Information Management System (IMS) prototyping and Version 0 interoperability involving all DAAC's will be maintained.

NASA selected the core system contractor for EOSDIS (Hughes Applied Information Systems, Inc.) in late 1992, with contract award planned for early 1993. NASA is progressing on the preliminary work with Pathfinder data sets to establish the Version 0 EOSDIS, providing researchers with early access to data sets from EOS precursor missions and from Earth probes flown before EOS. The major Version 0 event planned for 1993 is the first formal demonstration of the Version 0 prototype, to include the browse product integration, the integration with the Earth sciences Master Directory, and the graphical user interface and the data dictionary. The procurement process for the EDOS and IV & V segments is under way. NASA completed the ECOM requirements review, deciding to implement the ECOM segment in-house.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The changes in the FY 1993 budget estimates are a result of the realignment within the total EOS program. Funding for the science computing facilities and science data product capability development were reallocated to EOSDIS from the individual EOS missions. These adjustments include a $1.2 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funding is required to accomplish the first major EOSDIS milestone: completion of the Version 0 prototype information system for operational use by the Earth science research community. Version 0 will provide Earth science researchers with a comprehensive, interdisciplinary "Earth science view" of existing and near-term, pre-EOS NASA Mission to Planet Earth data. The Version 0 program will include development of interoperable linkages between DAAC's for IMS functions, including evolution toward a common user interface. Two prototype demonstrations for evaluation and test are scheduled for 1993, thus in early 1994, time will be devoted to incorporating recommended changes, streamlining the intended operations, and correcting software "bugs." Version 0 developers will complete the system architecture, with final integration and testing scheduled to be complete in 1994.

The EOSDIS Core System (ECS) development will also be fully under way in 1994, incorporating Version 0 capabilities, lessons learned, tested standards, etc. ECS is planned as an evolutionary development, with the initial release in 1995, supporting pre-EOS mission datasets. To support the 1995 ECS 1 release, both preliminary and critical design reviews are scheduled in 1994, in addition to a design review dedicated to the results of the Version 0 prototype. The independent verification and validation activities will also commence in 1994, in time to support the ECS design reviews. The EOS Data Operations System (EDOS) contract will be awarded to begin development for a 1998 operational readiness. In-house EOS Communications (ECOM) activities will be progressing toward the system CDR. A request for proposal for commercial communications software for ECOM will be released in early 1994, with award scheduled for late in the year.

BASIS OF FY 1994 FUNDING REQUIREMENT

EARTH PROBES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Scatterometer	28,000	20,200	20,200	18,700
Total ozone mapping spectrometer	30,800	18,700	27,685	9,800
Tropical rainfall measurement mission	19,000	50,000	51,528	68,800
Total	77,800	88,900	99,413	97,300
Launch vehicles (TOMS)	(6,300)	(1,200)	(4,200)	(1,800)

OBJECTIVES AND STATUS

The Earth Probes program is a component of Mission to Planet Earth that addresses specific, highly-focused problems in Earth science research. The program has the flexibility to take advantage of unique opportunities presented by international cooperative efforts or technical innovation. The Earth probe missions complement the Earth Observing System program by providing the ability to investigate processes that require special orbits or have unique requirements. The currently approved Earth probes are the Total Ozone Mapping Spectrometer (TOMS), NASA Scatterometer (NSCAT), and Tropical Rainfall Measurement Mission (TRMM). The first TOMS mission was delayed eight months due to cost growth in the instrument and spacecraft contracts.

The TOMS is a set of instruments and one spacecraft for launch on a small-class expendable launch vehicle in 1994, and on the Japanese Advanced Earth Observing System (ADEOS) Satellite in 1996. The first TOMS mission was delayed eight months due to cost growth in the instrument and spacecraft contracts. The ADEOS launch date was delayed one year by the Japanese due to problems in the development of the H-II launch vehicle. The TOMS instrument flights will provide uninterrupted data on total atmospheric ozone concentrations. The TOMS flights build on the experience that began in 1978 with the launch of a TOMS instrument on Nimbus-7 and continues with the TOMS instrument on the Russian Meteor-3, launched in 1991.

The NSCAT will provide accurate, global measurements of ocean surface winds, useful for both oceanography and meteorology. In addition, NSCAT data will permit the first global study of the influence of winds on ocean circulation, providing data on the effects of the oceans on the atmosphere and improved marine forecasting on winds and waves. The NSCAT will also fly on the Japanese ADEOS satellite in 1996.

The TRMM spacecraft will measure precipitation in the tropical latitudes from a dedicated Earth probe. The Japanese and the United States will sign a Memorandum of Understanding in 1994. The United States will provide the spacecraft, integration, and four instruments. The Japanese will provide the 1997 launch and a rain radar.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1993, $9.2 million was reallocated from the Payload and Instrument Development budget to the Earth Probes program. $8.7 million will fund cost growth in the TOMS instrument and spacecraft contracts, with $0.5 million to support development of the TRMM Microwave Imager instrument. These adjustments are increased by $1.3 million due to the redistribution of Research Operations Support (ROS) funding, $0.3 million for TOMS and $1.0 million for TRMM.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding is required to continue development of the NSCAT instrument, leading to a 1996 launch. In FY 1994, the NSCAT instrument will be integrated on the Japanese ADEOS tower, the spacecraft fixture on which NSCAT will operate, and shipped to Japan for spacecraft integration and testing. Additionally, the NSCAT science data processing will continue development. FY 1994 funding is also required for the system integration of the TOMS 1994 flight, including the satellite system environmental test, preparation of the satellite for launch, and associated on-site activities. In parallel, the ADEOS TOMS instrument will be fabricated, tested, and shipped to Japan for spacecraft integration and test. Development of TRMM will proceed in FY 1994 with design and development activities scheduled for the spacecraft, instruments, ground system, and the science data and information system. The TRMM spacecraft critical design review is scheduled for FY 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced communications technology satellite (ACTS)....................	18,700	3,600	3,968	3,000
Upper stage..........................	(16,700)	(7,400)	(17,500)	(--)

OBJECTIVES AND STATUS

The Advanced Communications Technology Satellite (ACTS) program will maintain United States leadership in the communications satellite market through the development and flight verification of advanced technologies that enhance the capability of communications satellites.

The United States user community, representing private sector organizations and other government agencies, will develop and execute experiments that will test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high effective isotropic radiated power: fast-hopping multiple beam antenna: on-board intermediate frequency and baseband switching: Ka-band components: and dynamic rain fade compensation techniques. The ACTS team has completed the final flight system testing in 1992 and in early 1993 delivered it to the Kennedy Space Center launch site for final integration with the Transfer Orbit Stage (TOS) and launch aboard the Space Transportation System (STS) in the summer of 1993. Final test of the ground system will be completed prior to launch.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The $0.4 million increase is due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget provides for the continuation of the mission operations for the ACTS flight and ground systems. Mission operations will continue for two years. The ACTS experiments program is funded and conducted under the Commercial Use of Space program.

BASIS OF FY 1994 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Atmospheric payloads..................	12,887	15,500	12,330	11,712
Earth sensing payloads................	25,013	33,900	23,131	11,188
Total...........................	37,900	49,400	35,461	22,900

OBJECTIVES AND STATUS

The objective of Atmospheric Payloads is to provide information related to the chemical constituency and dynamics of the Earth's atmosphere. The objective of the Earth Sensing Payloads is to demonstrate the technology and algorithms needed to make multi-frequency, multi-polarization active radar measurements of the Earth's surface (i.e., land, sea, and ice). Together, the two programs will provide measurements crucial to enhancing the understanding of the role of the Earth's atmosphere and surface during global change.

The Space Shuttle offers a unique opportunity for short-duration flights of instruments. The Mission to Planet Earth program has incorporated this capability into the Shuttle/Spacelab payload development in these important aspects: early test, checkout and design of remote sensing instruments for long-duration, free-flying missions and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical. Instrument development activities support a wide range of instrumentation, from airborne to international flights of opportunity.

The objective of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument first flew in 1985 on Spacelab-3 and again on ATLAS-1 in 1992. The science results from these flights of ATMOS were of exceptional value, and the basic capability of ATMOS to measure very low concentrations of trace species in the Earth's atmosphere was clearly demonstrated. The instrument is to fly again on ATLAS-2 and ATLAS-3 in 1993 and 1994.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas-filter correlation radiometer designed to measure the levels of troposphere carbon monoxide and the extent of inter-hemispheric mass transport in the lower atmosphere. The instrument was flown successfully on two Shuttle flights. It is planned for two more STS flights in 1994 to provide the first observations of the global seasonal variation of carbon monoxide in the Earth's atmosphere.

The Light Intersection Direction and Ranging (LIDAR) Technology Experiment (LITE) is an advanced technology Earth atmosphere sensing experiment incorporating the next generation of solid-state lasers. The laser application will provide measurements of higher resolution and accuracy than current spaceborne instruments of stratospheric and tropospheric aerosols, planetary boundary layer heights, and cloud top temperature and density.

Like LITE, the LIDAR Atmospheric Sensing Experiment (LASE) is also an advanced technology Earth atmospheric sensing experiment which will incorporate the next generation of solid-state lasers. Starting in FY 1994, NASA plans to fly the instrument routinely on the ER-2 aircraft to obtain water vapor measurements at improved resolution and accuracy than current instruments. These measurements will support studies in global hydrology, meteorology, radiation budget, climate and atmospheric transport, and chemistry.

The Solar Ultraviolet Spectral Irradiance Monitor (SUSIM) is designed to make very accurate measurements of the sun's ultraviolet radiation, which is the primary sources of energy for the Earth's atmosphere. SUSIM has flown on three previous STS flights and is planned for reflights on ATLAS-2 and ATLAS-3.

The Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument provides correlative measurements with SBUV/2 instruments that fly on NASA and NOAA spacecraft. Both instruments measure the amount and height distribution of ozone in the upper atmosphere. These measurements help resolve any data reliability problems resulting from calibration drift. SSBUV is planning to continue flights through the rest of the decade.

The Active Cavity Radiometer-1 (ACR-1) is designed to aid in the study of the Earth's climate and the physical behavior of the sun by making solar constant measurements. Reflights of ACR-1 on ATLAS-2 and -3 are planned for 1993 and 1994.

The Shuttle Imaging Radar-C (SIR-C) will explore regions of Earth's surface that are not well characterized because of vegetation, cloud, or sediment cover. These radar studies will lead to a better understanding of ocean and land surface, and subsurface processes on a global scale. Currently, SIR-C is in the environmental test and assembly phase with two launches aboard the Space Shuttle scheduled for 1994.

Advanced spectrometer technology development activities include fundamental research in remote sensing involving airborne and spaceborne imaging spectrometer instruments. The imaging spectrometer and linear array solid-state sensor research focuses on the development of such features as inherent geometric and spectral registration and programmable high spatial and spectral resolution.

CHANGES FROM FY 1993 BUDGET ESTIMATE

$9.2 million has been reallocated from the payloads program in order to provide $8.7 million to TOMS for instrument and spacecraft cost growth, and $0.5 million to TRMM to support development of the TRMM Microwave Imager instrument. These reductions have been accommodated through significant reductions in reserves and the deferral of advanced technology development activities. $5.1 million has been transferred to the Physics and Astronomy Shuttle/Spacelab Payload Mission Management and Integration budget to provide for the mission management and integration of ATLAS-3 and Shuttle Radar Laboratory (SRL) missions. These adjustments are partially offset by a $.3 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funds will be used to support the MAPS environmental testing with new ground support equipment. Funding for ATMOS, SUSIM and ACR-1 is required to support continuing flights in 1993 and 1994. This includes science team activities, data processing and analysis, and limited refurbishment. In FY 1994, the LIDAR program will have the flight model of the LASE instrument delivered, integrated and routinely flown on the ER-2 aircraft. The SIR-C and LITE experiments will be delivered to the Kennedy Space Center for integration, test and checkout prior to their 1994 launch.

BASIS OF FY 1994 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Upper atmosphere research satellite operations	30,515	35,400	36,663	31,000
Ocean topography experiment operations	4,846	29,000	31,614	31,200
Ocean color mission data purchase	13,000	14,900	15,570	9,600
Consortium for international Earth science information networks	25,000	--	12,300	--
Landsat	7,500	25,000	25,000	59,100
Earth science mission operations and data analysis	19,785	37,800	26,406	29,900
Total	100,646	142,100	147,553	160,800

OBJECTIVES AND STATUS

The objective of the Earth Science Mission Operations and Data Analysis program is to acquire, process, and archive long-term data sets produced by space missions. These data relate to issues of global change research in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for operations of spacecraft, processing of acquired data, validation of the resulting data products by science teams, and development of new processing software by these science teams.

The Upper Atmosphere Research Satellite (UARS) was launched in September 1991. The mission will provide data related to the chemistry and dynamics of the atmosphere above the tropopause for a period of at least three years. Various instruments aboard UARS are measuring temperature, composition, and winds in the Earth's atmosphere, as a function of altitude, over ninety-eight percent of the Earth's surface, from eighty degrees South latitude to eighty degrees North. These data will provide important information related to maintenance and destruction of the ozone layer. Correlative measurements are a key element of the UARS science objectives. Ground-based, balloon, and sounding rocket measurements of the

atmosphere are used to validate and calibrate UARS instrument measurements, refining the accuracy of the derived geophysical parameters. All UARS instruments are operational except for the United Kingdom's Improved Stratospheric and Mesospheric Sounder (ISAMS) instrument, which failed in July 1992.

NASA's Ocean Topography Experiment (TOPEX) and the French Poseidon mission were launched as a single ocean spacecraft mission, TOPEX/Poseidon, in August 1992. This mission will provide data on the surface topography and currents of the Earth's oceans for a period of at least three years. These data will provide critical information related to the circulation of the Earth's oceans and the Earth's climate.

In the ocean color mission data purchase, NASA will purchase ocean color data for research use from the SeaWiFS instrument launched on the SeaStar spacecraft in 1994. This imaging data, which will be obtained in several visible and infrared wavelengths, will be processed and archived, resulting in long-term data sets related to the biological productivity and ecology of the world's oceans, seas, and larger lakes.

On Nimbus-7, the Stratospheric Aerosol Measurement II (SAM-II) instrument continues to add to a twelve-year data set on atmospheric aerosols and stratospheric clouds in the Earth's polar regions. Data from the Total Ozone Mapping Spectrometer (TOMS) instrument on Nimbus-7 continue to provide accurate maps of total atmospheric ozone, as they have since launch in 1978. This instrument was joined in space by a TOMS instrument on the Russian Meteor-3 spacecraft launched in 1991.

Data from the Solar Backscatter Ultraviolet/2 (SBUV/2) instruments, on the NOAA-9 and NOAA-11 satellites, provide column abundances and vertical profiles of atmospheric ozone beneath the orbital tracks of these satellites, continuing the collection of a data set begun with the SBUV instrument on Nimbus-7 in 1978. A carefully calibrated version of the same instrument, called Shuttle SBUV (SSBUV), has been flown four times on the Space Shuttle and will continue to fly periodically in the 1990's. The SSBUV provides correlative measurements so that the TOMS and SBUV instruments flying on other spacecraft can be more accurately calibrated, and provides information on the diurnal variability of stratospheric ozone in low latitudes.

On the Earth Radiation Budget Satellite (ERBS), data from the Stratospheric Aerosol and Gas Experiment II (SAGE-II), launched in 1984, continue to provide vertical profiles of aerosols, ozone, and other trace gas species over the Earth's tropical and mid-latitude regions.

The Earth Radiation Budget Experiment (ERBE) is comprised of three identical instrument packages flying on NOAA-9, NOAA-10, and NASA's ERBS. These instruments continue to provide data on the temporal and spatial variations in the Earth's radiation budget, which drive the Earth's climate. Data from the Earth Radiation Budget (ERB) instrument on Nimbus-7, and from the ERBE instruments, provide the only continuous data set on total solar irradiance (solar constant) and its temporal variations stretching from 1978 to the present.

NASA's Alaska Synthetic Aperture Radar Facility (ASF), based at the Geophysical Institute at the University of Alaska in Fairbanks, began acquisition and processing of Synthetic Aperture Radar (SAR) data transmitted from the European Space Agency's Earth Remote Sensing Satellite-1 (ERS-1) in early 1991 and the Japanese Earth Remote Sensing Satellite-1 (JERS-1) in mid-1992. Data from the Canadian RadarSat spacecraft will also be acquired and processed after its launch in 1995. These data will provide important information on the properties and dynamics of sea ice and other land and ocean processes in the polar regions.

The Consortium for International Earth Science Information Network (CIESIN) serves as an affiliated data center for NASA's EOSDIS program. It will facilitate the access to and use of Mission to Planet Earth data for Earth science research and public policy making. The CIESIN is currently analyzing existing and prospective Earth science research information resources and current national and international plans for data integration, analysis and modeling.

The Federal Government is committed to the continued acquisition of Landsat-type data for national security, global change research, and other Federal, state, local, and private sector users needs. The Department of Defense (DOD) is responsible for the procurement and launch of the Landsat-7 spacecraft, with NASA responsible for flight operations and data processing, distribution and archival. The contract for procuring Landsat-7 was awarded by DOD in October 1992.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase of $5.5 million reflects a Congressionally-directed general reduction of $15.0 million, offset by the addition of funding for the CIESIN program, and a $0.5 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Operations of the Nimbus-7 and ERBS spacecraft and processing and analysis of their data will continue, as will processing and analysis of data from NOAA-based and Shuttle-based SBUV instruments. Processing and analysis of SAR data acquired at the ASF from European Space Agency's ERS-1 will also continue and be augmented by similar processing and analysis of SAR data from Japan's JERS-1. Operations of the TOPEX spacecraft and processing and analysis of its data will continue. Operation of the UARS spacecraft will continue to the end of FY 1994. Processing and analysis of data from the TOMS instrument flying on the Russian Meteor-3 spacecraft will continue. Processing and analysis of data from various NASA SAR instruments (including an airborne version) will continue, in preparation for flight on SIR-C in 1994. Funding will be continued to allow for the eventual purchase, processing, and analysis of ocean color data.

Development of the ground segment (ground processing and mission operations systems) of the Landsat program as well as a Tracking and Data Relay Satellite System (TDRSS) communication antenna for the Landsat-7 satellite will continue. The ground processing system will include satellite command, control, telemetry, data processing, product generation, and data archival. An early priority will be to preserve the existing Landsat 1-5 archive by transferring the data to a more stable medium. FY 1994 funding requirements for the CIESIN program are under review and will be submitted to the Congress on the same schedule as that of the Space Station redesign.

BASIS OF FY 1994 FUNDING REQUIREMENT

INTERDISCIPLINARY RESEARCH AND ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Interdisciplinary research and analysis...........................	2,340	2,600	4,453	5,000

OBJECTIVES AND STATUS

Interdisciplinary research activities are conducted to characterize quantitatively the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and the atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes. Such research is essential to investigating and assessing long-term physical, chemical, and biological trends and changes in the Earth's environment. Included in the program activities are joint efforts from a variety of disciplines, such as atmospheric science, climatology, biological sciences, geochemistry, and oceanography.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The $1.9 million increase is due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of oceanic processes, atmospheric dynamics and radiation, upper atmosphere/troposphere chemistry, and land processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific pilot studies such as those understanding the biogeochemical processes controlling the concentration of atmospheric methane, characterizing changes in properties of the land surface and their effect on climate, and understanding the role of the oceans in the global carbon cycle.

BASIS OF FY 1994 FUNDING REQUIREMENT

MODELING AND DATA ANALYSIS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Physical climate and hydrologic systems modeling and data analysis..........	29,463	28,000	26,862	27,100
Biogeochemistry and geophysics modeling and data analysis..................	16,335	17,000	15,709	17,900
Total...........................	45,798	45,000	42,571	45,000

OBJECTIVES AND STATUS

The research and analysis activities within the Physical Climate and Hydrologic System program provide a focus for contributing to an improved understanding of the fully-integrated geophysical climate system, its interactions and predictability, through the development and multi-disciplinary exploitation of global satellite observations of the Earth, numerical modeling, climate impact assessments, and sensitivity studies. The two principal components of the program are in the areas of climate modeling research and climate data analysis.

The objectives of the Physical Climate and Hydrologic Systems Modeling Research program are to develop and improve global circulation models which assimilate and optimize the use of satellite-derived data sets for understanding climate interactions; to help guide the design of the global observing system, and to improve the capability for reliable climate diagnosis and forecasting. The program builds on the broad foundation established over the past decade of research on geophysical modeling conducted under the NASA atmospheric dynamics and radiation and ocean processes programs.

The objectives of the Physical Climate and Hydrologic Data Analysis program are to assemble a long-term global record of climate parameters, with an emphasis on satellite remote sensing, for specifying and analyzing the state of the climate system and its variability. These include the full range of geophysical variables which describe the structure and composition of the atmosphere, oceans, land surfaces, and cryosphere, as well as their boundaries, interfaces, and external forcings. The program builds on earlier accomplishments achieved through such diverse research initiatives as the International Satellite Cloud Climatology Project (ISCCP), the Earth Radiation and Budget Experiment (ERBE), the Global Atmospheric

Research Program (GARP) and current activities in support of the Tropical Oceans Global Atmosphere Program (TOGA) and the World Ocean Circulation Experiment (WOCE). These programs are elements of the World Climate Research Program (WCRP), sponsored by the World Meteorological Organization and the International Council of Scientific Unions. Such international relationships are strongly encouraged by the U.S. Global Change Research Program plan.

The Biogeochemistry and Geophysics Modeling and Data Analysis has as its objectives the development of global change models dealing with all aspects of the biology, chemistry, geology, and geophysics of the Earth system, with the exploitation of satellite data in the monitoring of global change as well as the study of the mechanisms which are at work in the global environment. There are four major elements to the program: ocean biogeochemistry, atmospheric chemistry, geophysical modeling and analysis, and ecology and land atmosphere interactions.

In the ocean biogeochemistry program element, the emphasis is on data analysis efforts utilizing existing satellite data sets to understand better the variations in ocean productivity and preparing improved algorithms and data systems for the Ocean Color Mission.

The atmospheric chemistry program element is centered on the numerical modeling and analysis of measurements trace constituents in the troposphere-stratosphere system. Numerical models are used to test our understanding of atmospheric chemistry and of the way in which meteorological processes affect the trace constituent distribution in the atmosphere. Models are also used to predict future changes to the chemical composition of the atmosphere.

Research in geophysical modeling and analysis consists of modeling and analysis of the Earth's internal structure and dynamics through measurements of the gravitational and magnetic fields, Earth rotation and polar motion, and geodetic properties. The spatial variability of the potential fields and the temporal variability of the motion fields are the critical observational parameters.

In the ecology and land atmosphere interactions program element, global scale observations are analyzed to understand the current state of terrestrial ecosystems, to assess their natural variability, and to determine the impacts of anthropogenic forcings. Numerical models and multi-temporal satellite observations are used to study sources and sinks of biogeochemical species and to investigate the interactions of climatic events such as El Nino with surface biology and atmospheric composition. Theoretical modeling of ecosystem functioning and land atmosphere interactions is conducted using global circulation models with explicit, interactive biospheres.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Modeling and Data Analysis was reduced by $3.6 million to fully fund the FY 1993 request for Landsat. This reduction is offset by a $1.5 million increase due to the redistribution of Research Operations Support (ROS) funding and a $0.3 million internal adjustment.

BASIS OF FY 1994 ESTIMATE

The ocean biochemistry program element will increase the emphasis on modeling of the chemical interactions between the oceans, land and atmosphere. In atmospheric chemistry, emphasis on multi-dimensional modeling of the troposphere will be increased. The studies in ecology and land atmosphere interactions will place increased emphasis on ecosystem sources of key trace species in the atmosphere.

The analysis of ERBE data will lead to reliable predictions of climate change at the regional level using general circulation models. The SeaWiFS science team will begin their analysis of ocean color data from the new satellite. Initial focus will be on defining higher level data products needed for global change studies. The newly formed Nimbus-7/METEOR-3 TOMS science team begin similar activities to define data products, especially those needed for impact assessments. In all program elements, new work will emphasize analysis of existing data sets generated within the NASA pathfinder program.

BASIS OF FY 1994 FUNDING REQUIREMENT

PROCESS STUDIES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Radiation dynamics and hydrology.......	33,166	34,000	31,560	34,700
Ecosystem dynamics and biogeochemical cycles..............................	23,300	23,100	23,679	26,800
Atmospheric chemistry..................	29,873	30,300	28,111	32,000
Solid Earth science....................	25,900	30,200	27,680	28,700
Laser research facilities..............	9,300	9,000	8,225	9,300
Total..............................	121,539	126,600	119,255	131,500

OBJECTIVES AND STATUS

The research and analysis activities within the Radiation Dynamics and Hydrologic Processes program combine a core effort of theoretical, laboratory, and field investigations essential to understanding the basic geophysical processes and their interactions which control climate. The two principal components of the program are in the areas of radiation and dynamic processes research and hydrologic processes research.

The objectives of the radiation and dynamics research program are to improve our understanding of the basic physical processes by which the atmospheric system transforms, stores and transports energy. Understanding atmospheric dynamics is essential to understanding how the atmosphere behaves and its role in determining climate and climate change.

The objectives of the hydrologic processes research program are to improve our understanding of the physical processes which govern the hydrological cycle and its impact on the atmosphere and oceans. The prediction of global change in the geosphere and biosphere will be one of the most important problems in environmental sciences in the twenty-first century. Estimation of the distribution and transport of carbon, nitrogen, sulfur, etc., cannot be obtained without knowledge of the atmospheric circulation and water cycle on regional and global scales.

The Ecosystem Dynamics and Biogeochemical Cycles program conducts research on the function of global ecosystems and the interactions of the Earth's biota with the atmosphere and hydrosphere. Particular emphasis is placed on understanding land atmosphere interactions and the carbon cycle. The two principal components of the program are the ecosystem dynamics program element and the biogeochemical processes program element.

The goal of the ecosystem dynamics program element is to achieve an improved understanding of the role of the biosphere and the biologically-linked components of the hydrologic cycle in processes of global significance. Specific objectives are to develop understanding of the ecological controls on the exchanges of energy, water, and nutrients between ecosystems and the atmosphere, the response of ecosystems to change, and the biophysics of remote sensing of ecosystem properties.

The goal of the biogeochemical processes program element is to achieve an improved understanding of the sources, sinks, fluxes, trends, and interactions involving the biogeochemical constituents within the Earth system, with an emphasis on their major biospheric reservoirs, including oceanic and terrestrial systems. A major focus is on developing a better understanding of terrestrial and oceanic primary productivity and the fluxes of carbon within these ecosystems and between them and their biotic environment.

The Atmospheric Chemical Processes program is composed of two elements: the upper atmospheric research program (UARP) and the tropospheric chemistry program (TCP). The UARP is a large, comprehensive research program with NASA playing a leadership role as mandated by Congress under the Clean Air Act of 1976 and the FY 1976 NASA Authorization Act. The program aims at expanding our knowledge of the physical, chemical, and meteorological processes that control the concentration and distribution of atmospheric ozone, thereby providing the necessary input for large-scale global models used to predict the future state of stratospheric composition. The TCP is focused on tropospheric chemical change, the natural and anthropogenic processes that cause it, and its effects on global climate and on the chemistry of the stratosphere through troposphere-stratosphere exchange.

One of the primary challenges in the study of the Earth as a system is understanding the extent and causes of atmospheric chemical changes and their consequences, including stratospheric ozone depletion and potential global climate change.

The Solid Earth Science program conducts research in the fields of geology and geodynamics with the goal of improving our understanding of the evolution, structure, and dynamics of the Earth's interior and surface by testing hypotheses through a vigorous program of measurement and analysis of space-based geodetic, remote sensing, space-based geopotential, and related data. In geodynamics, emphasis is placed on understanding the rates and mechanisms of the Earth's crustal deformation from local to global scale and how these reflect historical global change or influence current processes of global change. In geology, emphasis is placed on the interaction of the solid Earth with the hydrosphere, atmosphere and biosphere in programs under development and implementation in the early 1990's which address soil development and erosion, volcano-climate interaction, and coastal processes.

The objective of the Laser Research program is to measure the movement and deformation of the tectonic plates of the Earth. Laser ranging to satellites and the moon, microwave interferometry using astronomical radio sources and transmissions from the Global Positioning Satellite system (GPS) are used to determine precise position locations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Process Studies program was reduced by $11.4 million to fully fund FY 1993 requirements for Landsat. Biochemical processes was increased $1.6 million through the transfer of the Biospheric program from Life Sciences. These adjustments are increased by $2.5 million due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

FY 1994 funding is required in the area of radiation and dynamics research to continue studies of the processes associated with cloud-radiation feedback, ocean circulation and heat flux. Research and analysis studies will continue, focusing on forest ecosystem dynamics, marine primary productivity, regional trace gas fluxes, and the biophysics of remote sensing. Analysis of the First International Satellite Land Surface Climatology Project (ISLSCP) Field Experiment (FIFE) data set, Hydrologic Atmosphere Pilot Experiment (HAPEX)-Sahel experiment data, and various multi-sensor airborne campaign data sets will continue. Both of the atmospheric chemical process programs will continue their activities to investigate and understand the global atmosphere through laboratory studies and field measurement campaigns. The solid Earth program will pursue its geodynamics research activities in large part through the Fiducial Laboratories for International Natural Science Network. The geodynamics program will continue definition studies to develop, in partnership with the European Space Agency (ESA), a Gravity and Magnetic Experiment Satellite (GAMES), using gravity radiometry and magnetometers to study at high resolution the variability of Earth's gravity and magnetic fields.

BASIS OF FY 1994 FUNDING REQUIREMENT

AIRBORNE SCIENCE AND APPLICATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Airborne science and applications......	20,300	22,900	20,707	25,200

OBJECTIVES AND STATUS

The Airborne Science and Applications effort requires operation of ER-2, C-130, and DC-8 aircraft in order to support Earth remote-sensing and atmospheric research. They may serve as test beds for newly-developed instrumentation and allow demonstration of new sensor techniques before their flight on satellites or on Shuttle/Spacelab missions. Data obtained from these aircraft are used to refine analytical algorithms, and to develop ground data handling techniques. For example, the ER-2 acquires stratospheric air samples and conducts in-situ measurements at altitude ranges above the capability of more conventional aircraft and below those of orbiting satellites. This capability is important in gaining an understanding of stratospheric transport mechanisms. The DC-8 carries a wide variety of instruments, ranging from a large complement of atmospheric sensors, to LIDAR's and a three-frequency synthetic aperture radar used in surface process studies. The program is also responsible for all maintenance, system upgrades and spares for the aircraft.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Airborne program was reduced by $3.1 million consistent with Congressional direction. This has resulted in a deferral of all environmental research conducted aboard the C-130 aircraft until FY 1994. Required ground maintenance of the aircraft will continue in the interim. These adjustments are offset by a $0.9 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

The Airborne Research Program provides a variety of platforms in support of studies of the biosphere, troposphere and stratosphere. Platforms include a modified C-130, a long-range DC-8 that has been uniquely modified to accommodate a wide variety of specialized instrumentation for atmospheric and Earth surface remote sensing studies, and high-altitude ER-2's, which are a unique national resource. Several major campaigns are in the planning stages, including a nearly year-long investigation of the Antarctic ozone.

The ozone flights are tentatively planned for Christchurch, New Zealand. The international BOREAS campaign, which will involve all the platforms, is planned for nearly nine months, with basing in the United States and Canada. Another Global Tropospheric Experiment over the north Pacific using the DC-8 will be conducted over a six-week period in early 1994. In addition, the DC-8/AIRSAR (Airborne SAR) system will underfly the SIR-C (Shuttle) mission in 1994. An ER-2 will also be used for a large number of LIDAR Atmospheric Sensing Experiment (LASE) instrument (airborne LIDAR) tests.

The majority of these science flights are related to EOS investigations - contributing to algorithm development for EOS precursor instruments, and supporting individual university principal investigator research studies. The NASA airborne platforms also support other Federal agencies in support of their specific global research.

BASIS OF FY 1994 FUNDING REQUIREMENT

MISSION TO PLANET EARTH INFORMATION SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission to planet earth information systems............................	(35,000)	(40,700)	(36,193)	11,800

OBJECTIVES AND STATUS

Through FY 1993, the Information Systems program is made up of four major discipline areas: scientific computing, science data management and archiving, science networking, and information systems research and analysis. In addition, the important function of conveying facts about NASA's information and data management systems is part of program management responsibility. Beginning in FY 1994, the ongoing Information Systems program has been reallocated among the Space Science and the Mission to Planet Earth programs.

The information systems program within the Mission to Planet Earth program provides scientific computing support to further the Mission to Planet Earth research goals. The specific emphasis is access to supercomputing capability for the large-scale numerical models which simulate physical, chemical, and dynamic processes in the Earth environment. This is done primarily through the NASA Center for Computational Science (NCCS) at the Goddard Space Flight Center (GSFC) and the supercomputing facility at the Jet Propulsion Laboratory (JPL). Both facilities continue to upgrade capacity to keep pace with growing requirements. A major replacement to a new technology supercomputer at the NCCS is planned for the last quarter of 1993.

The information systems role in the High Performance Computing and Communications (HPCC) program will lead to advances in computing and related technologies to further Mission to Planet Earth objectives related to global change.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The change from the FY 1993 Budget Estimate is due to a Congressional reduction of $5 million and has been accommodated by deferring some planned activities. This adjustment was offset in part by a $0.5 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

Beginning in FY 1994, support for NASA's Information Systems program will be divided between the Mission to Planet Earth and the Space Science programs. Space Science will support three of the four areas of science data management and archiving, science networking, and information systems research and analysis. Mission to Planet Earth Information Systems will continue scientific computing.

The funding will continue the NCCS at GSFC and the JPL supercomputer, including enhancements to keep pace with requirements. The NCCS will upgrade to the latest technology supercomputer system in the first quarter of FY 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research operations support...........	83,909	98,000	70,061	67,000

OBJECTIVES AND STATUS

Research Operations Support (ROS) funding provides vital support to the civil service workforce and to the physical plant at the Centers and at NASA Headquarters. This funding supports the basic core administrative functions such as personnel, payroll, accounting, procurement and legal counsel. It also supports centerwide services for civil service staff, such as mail, telephones, janitorial services, transportation, medical (other than astronaut), security, and fire protection, as well as maintenance of roads, grounds, and all requirements of administrative buildings. Funding to support activities which directly benefit the NASA programs are included in the program budgets.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1992, establishment of the ROS was initially accomplished by transferring funds contained in the Operation of Installation account in the Research and Program Management appropriation to the Research and Development and Space Flight, Control and Data Communications appropriations. During FY 1993, a more detailed examination of activities supported by ROS funding was conducted by the program offices to identify activities directly related to program activities. Funding for activities dedicated to a single program was transferred to the benefiting program. In total, the decrease in ROS funding reflects the transfer of $22.1 million consistent with the restructuring activity offset by a reduction of $5.8 million consistent with Congressional direction to reduce ROS funding.

BASIS OF FY 1994 ESTIMATE

The FY 1994 estimate is the result of intensive cost cutting activities which respond to NASA's internal commitment to hold down costs in all areas and also to the recent executive order mandating reductions in administrative expenses. As such, it reflects the minimum funding to support administrative and facility maintenance requirements at the NASA Centers and NASA Headquarters. This includes administrative services that support all civil service employees, facility maintenance, maintenance of roads, grounds and requirements of administrative buildings.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

SPACE RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base...........	140,850	173,800	158,113	160,800	RD 7-6
In-Space technology experiments program	15,074	--	--	--	
Civil space technology initiative (CSTI) program......................	82,948	158,200	114,616	137,400	RD 7-18
Space automation and telerobotics......	37,900	--	--	--	
Exploration technology program.........	28,900	--	--	--	
Exploration mission studies............	3,500	--	--	--	
Total..........................	309,172	332,000	272,729	298,200	

Distribution of Program Amount By Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Stennis Space Center..................	640	500	270	300
Johnson Space Center..................	15,090	14,100	6,550	7,700
Kennedy Space Center..................	2,673	4,600	2,380	3,800
Marshall Space Flight Center...........	25,202	27,500	20,000	23,300
Goddard Space Flight Center............	21,845	18,500	16,803	23,800
Jet Propulsion Laboratory..............	44,186	48,800	49,450	56,700
Ames Research Center..................	31,643	35,400	23,906	28,600
Langley Research Center................	55,066	61,800	47,525	50,600
Lewis Research Center..................	72,939	75,700	64,703	66,300
Headquarters..........................	39,888	45,100	41,142	37,100
Total..........................	309,172	332,000	272,729	298,200

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

OBJECTIVES AND JUSTIFICATION

In 1993, the Office of Commercial Programs (OCP) and the Space Research and Technology program of the Office of Aeronautics and Space Technology (OAST) were merged to create a new organization, the Office of Advanced Concepts and Technology (OACT). The OACT will be the NASA focal point for technology innovation and transfer. The focus of the new office will be to support the development and application of technologies critical to the economic, scientific, and technological competitiveness of the U.S. and to promote U.S. industrial preeminence through strengthened linkages between the private sector and NASA technology efforts.

Specifically, the mission of OACT is to pioneer innovative, customer-focused space concepts and technologies, leveraged through industrial, academic, and government alliances to ensure U.S. competitiveness and preeminence in space. Several goals for the new organization have been established:

- to be a center of systems engineering excellence performing concept definition and evaluation studies for NASA, industry, and commercial applications;
- to be a nationally recognized customer-oriented focal point for solicitation, evaluation, and implementation of innovative technology and products for space and terrestrial applications;
- to establish new alliances and mechanisms to develop and transfer technology to create new self-sustaining industries, improve performance, reduce costs, and demonstrate benefits and potential of dual-use technology; and,
- to develop and promote the unique attributes of space for new commercial products and services.

In FY 1994, OACT will complete the refocus of its programs and begin a more aggressive pursuit of the transfer of technology from NASA to the private sector, enhanced partnerships between the private sector and NASA, and development of critical technologies essential to future NASA and commercial missions. Following is a description of the OACT activities, the Space Research and Technology program and the Commercial programs.

The overall goal of the Space Research and Technology program is to provide advanced, enabling technologies, validated at a level suitable for user-readiness, for future space missions. To achieve this goal, the Space Research and Technology program will continue to support a broad-based activity to advance the state-of-the-art at the concept, subsystem and system level; to develop technical strengths in the engineering disciplines within NASA, industry, and academia; and to perform critical flight experiments in areas where testing in the space environment is necessary for technology development.

In FY 1994, the Space Research and Technology program will consist of two complementary parts: the Research and Technology (R&T) Base and a focused program, the Civil Space Technology Initiative (CSTI). The R&T Base program will continue to serve as the seedbed for new technologies and capability enhancement. Fundamental research will be conducted in critical disciplines, and high-leverage technology advances and concepts will be brought to the level of demonstrating proof of principle. The In-Space Technology Experiments program, now as part of the R&T Base, will continue to support the development of small flight experiments to conduct research and to validate critical technologies that cannot be accomplished on the ground.

The CSTI is composed of five strategic thrusts -- space science technology, transportation technology, planetary surface technology, space platforms technology, and operations technology which are intended to be highly responsive to the user community's needs. The CSTI, as a focused program, will continue to provide specifically for the development of selected technologies at larger scale or higher level of maturity and, as required, in the relevant environment of space, for more effective transfer to the user programs. These advanced technology efforts will significantly enhance current capabilities to access, operate in, and explore space. The technology developed by these efforts will reduce mission costs and increase safety and reliability.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Space Research and Technology program has been reduced by a net amount of $59.3 million. This reduction is the result of a Congressional general reduction of $65.0 million (which was allocated by reducing the R&T Base by $18.5 million and CSTI by $46.5 million), a reallocation of $5.1 million of hypersonic funding to the Aeronautical Research and Technology Base, a reallocation of $0.1 million to Research Operations Support (ROS) in the Aeronautics Research and Technology budget offset by the transfer of $10.9 million due to the redistribution of the ROS funding program.

BASIS OF FY 1994 ESTIMATE

The FY 1994 Space Research and Technology program is a critical step towards responding to the strong and continuing consensus that investments in advanced research and technology (R&T) are essential to our future success in space. A healthy and aggressive Space Research and Technology program is a vital element in

contributing to our National competitiveness. The FY 1994 Space Research and Technology program will continue to assure the effective development of the advanced technologies necessary for our Nation's future space missions. The narratives that follow discuss in greater detail highlights of FY 1993 accomplishments and planned FY 1994 activities.

In FY 1994, the Research and Technology Base program will continue to serve as the seedbed for new technologies and capability enhancement. Several changes initiated in FY 1993 in the research and technology base will continue, such as increased emphasis on high-leverage technologies, including control of space structures, automation and robotics and micro spacecraft technology development. Other changes in FY 1993 include the consolidation of five of the R&T Base programs which were formally implemented at up to six field centers. The number of field centers have been reduced to two or three to increase management and funding efficiency.

The CSTI program focuses on research in five categories: space science, planetary surface, transportation, space platforms and operations. The CSTI is a vital component of NASA's Space Research and Technology program, intended to build NASA's technical strength and to provide options for high-priority future civil space goals. Over the last few years, the ongoing CSTI program has been severely constrained. Throughout the program there are key activities that need to be revitalized to keep America at the forefront of research and technology. The CSTI's research efforts are critical to ensure that the capabilities to accomplish future space missions will be available when needed. The following discusses the CSTI program thrusts.

The space science technology thrust is developing the advanced technology for observations from future space and Earth science missions. Specific program areas are in science sensing and observatory systems. The principal program emphasis will be on creating technology options and improvements for the next decade's space science missions, such as the Earth Observing System (EOS), as well as providing the enabling technologies for missions beyond the end of the decade. In FY 1994, continuing efforts will be expanded in direct detectors, submillimeter sensing, laser sensing, coolers and cryogenics, and micro-precision controls/structures integration.

The planetary surface technology thrust will focus on technologies for the robotic exploration of the solar system to support future science missions. In particular, the program will develop technology for small rovers that could be used for the scientific exploration of Mars.

The transportation technology thrust is primarily concerned with providing the technology needed for future major transportation improvements. The overall goal of the transportation technology thrust is to develop and validate technologies that will provide new capabilities for current and future space transportation vehicle systems, reduce life-cycle costs, substantially improve safety margins and reliability, and increase system availability. In FY 1994, additional emphasis also will be placed on facilitating the transfer of these emerging technologies to the commercial space sector through joint or cooperative activities with industry.

The space platforms technology thrust is primarily concerned with providing the technology needed for future space platforms for the following mission classes: unmanned Earth orbiting platforms in low-Earth orbit or geosynchronous Earth orbit, manned Earth orbiting platforms (space stations), and deep-space platforms. The overall technology goal is to enhance future science, exploration, and commercial missions by providing lightweight, durable, stable, and accurately pointed platforms, and highly efficient platform utilities. Once achieved, these advances will lead to reductions in spacecraft launch weight, (reduced life-cycle costs by decreasing on-orbit maintenance and logistics resupply needs) and increased lifetime operability. In FY 1993, new emphasis was placed on micro-spacecraft technology for the early design studies of Earth Probe missions and outer planet missions. This focus will continue in FY 1994.

The goal of the operations technology thrust is to develop, validate, and transfer technologies to reduce the cost of NASA operations, improve the safety and reliability of those operations and enable new, more complex, activities to be undertaken. It will also provide the high capacity data transfer, storage and processing that is implicit in expanding scientific and exploration endeavors. Significant results have already been achieved, and the program will build on these successes in the future. The thrust will provide technology for NASA users and the commercial sector and will support major operational improvements for future robotic and human missions both on the Earth and in space.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aerothermodynamics research and technology	14,400	14,400	10,400	10,200
Space energy conversion research and technology	11,403	12,600	10,800	10,800
Propulsion research and technology	15,258	14,700	12,900	13,100
Materials and structures research and technology	21,797	23,500	21,000	21,100
Space flight research and technology	16,530	16,000	12,700	13,200
In-space technology experiments program	(15,074)	16,700	19,200	19,700
Systems analysis	6,523	6,400	6,613	8,400
University space research	17,130	18,600	18,600	18,600
Information and controls technology	10,369	21,300	17,500	17,500
Human support technology	7,186	8,100	9,200	8,900
Space communications	20,254	21,500	19,200	19,300
Total	140,850	173,800	158,113	160,800

OBJECTIVES AND STATUS

The objective of the Research and Technology Base program is to gain greater knowledge and understanding of the fundamental aspects of phenomena in critical engineering disciplines and to provide needed technology products for both near- and far-term missions. The Research and Technology Base program consists of nine program elements: aerothermodynamics, space energy conversion, propulsion, materials and structures, space flight, systems analysis, information and controls, human support, and space communications. In addition, the university space research program, supported by the research and technology base, includes research in critical areas to enhance and broaden the capabilities of the Nation's academic community to participate more effectively in the U.S. civil space program. A description of the objectives and status of the elements of the Research and Technology program follows.

The Aerothermodynamics program provides for fundamental understanding and prediction of the detailed aerodynamic and thermodynamic loads experienced by high-speed vehicles during ascent, entry and maneuver in both the Earth and other planetary atmospheres. This activity is enabling to the successful development and design of advanced aerospace vehicles and is pursuing the following objectives: (1) development and application of advanced computational methods and numerical techniques covering the entire spectrum of continuum, transitional, and rarefied flows; (2) development of accurate and detailed real-gas chemistry and high-speed turbulent flow models and the efficient integration of these models with standard computational flow codes; (3) establishment of a high-quality ground and flight experimental data base for code validation and verification; (4) direct correlation and comparison of computations with available ground and flight data; (5) establishment of a detailed aerothermal loads data base and development of fully integrated analysis techniques; and (6) enhancement of engineering design codes and advanced configuration analysis capability to support rapid evaluation of future vehicle/mission concepts. In FY 1993, significant accomplishments included the successful completion of the analysis of Space Shuttle leeside heating and demonstrated agreement with the Orbiter Experiments program (OEX) Shuttle Infrared Leeside Temperature Sensing (SILTS) flight measurements. The program also completed the HL-20 personnel launch system (PLS) concept definitions and configuration analysis. Progress continues to be made in development of advanced computational fluid dynamics (CFD) codes which incorporate thermochemical nonequilibrium effects and coupled radiation; development of a flight test capability sufficient to validate computational predictions and provide correlation for ground test data bases; and extending the level of sophistication and efficiency of engineering design codes for configuration assessment.

The objective of the Space Energy Conversion program is to provide the space power research and technology base for future Agency and national needs. Major thrusts are to improve performance, reliability and tolerance to the atomic oxygen, plasma and radiation environments while reducing power system cost and mass for systems operating in low-Earth orbit (LEO), geostationary orbit (GEO) and planetary environments. The research is aimed at providing the technology base for power systems ranging from 10's of watts to 10's of kilowatt (kW) to eventually megawatt electric (MWe) levels. Areas include photovoltaics, electrochemical energy storage, fault tolerant power management and distribution components and subsystems, spacecraft environmental interactions, integrated spacecraft bus technology, solar thermal and dynamic systems, advanced radiator concepts and surfaces, and thermal control of advanced power electronics. Significant technical accomplishments in FY 1992-FY 1993 include the development of a fiber optic current sensor technology; progress in photovoltaics systems with five times improvement in watts to kilogram (w/kg), Ni-H2 batteries with two times W-hr/kg and ten times improvement in LEO lifetime and successful demonstration of a thermal energy conversion system, alkalai metal thermal to electric conversion (AMTEC) technology system, with improvements of twice the lifetime (1900 hours) and a 13 percent increase in efficiency. Major progress has also been made in the space environmental compatibility area leading to castings and spacecraft designs that have been incorporated into satellites to ensure long-lived performance in this harsh environment.

The Propulsion program defines, develops and transfers technologies for future NASA, commercial, and Department of Defense (DOD) transportation missions. Applications include launch to orbit transfer, and ascent/descent vehicles, planetary spacecraft and Earth-orbiting satellites utilizing both chemical and electrical propulsion systems. Emphasis is placed on technologies which materially add to U.S. capabilities and competitiveness in space. Advanced propulsion concepts which can be developed into spacecraft propulsion systems capable of strongly enhancing the missions of interest to NASA in the first decades of the 21st century will be evaluated. Systems studies will be performed to assess the theoretical benefits of proposed advanced propulsion concepts in terms of quantifiable attributes such as required initial mass in Earth orbit or flight time. Significant technical accomplishments in FY 1992-FY 1993 include the selection of arcjet propulsion technology for orbit control on four new commercial satellite systems; the baselining of high temperature-oxidation resistant coated apogee engines on a new commercial satellite; and the baselining of plasma contactors on the Space Station which are directly derived from ion propulsion technologies.

The Materials and Structures program focuses on extended space durability and environmental effects, lightweight structures for space systems, and technology to enable the development of space structures and advanced space transportation systems with significant improvements in performance, efficiency, durability, and economy. Materials technology focuses on: fundamental understanding of the processing, properties and behavior of advanced space materials; development of lightweight space-durable materials; computational methods in chemistry to enable the prediction of physical properties and environmental interactions involving materials under space and reentry conditions; nondestructive measurement science for advanced materials; tribological aspects of materials behavior in the space environment; and the development of a wide variety of metallic, intermetallic, ceramic and carbon-carbon materials for thermal protection systems. Structures technology focuses on: the development of erectable and deployable structural concepts; methods for in-space construction, monitoring, and repair of large complex structures; dynamics of flexible structures and vibration suppression; new structural concepts for cryogenic tanks for advanced Earth-to-orbit rocket propulsion systems, future space transportation vehicles, and orbital transfer vehicles; and efficient analysis and design methodology for advanced space structures, including multidisciplinary analysis and optimization. During FY 1992, continued analysis of the data returned by the Long Duration Exposure Facility (LDEF) has contributed to the knowledge of the low-Earth environment, improved models for the prediction of meteoroid and debris fluxes, provided data on performance of a wide variety of coatings and prediction of long-term performance of selected exterior spacecraft materials, and is continuing to prove valuable in the development of a comprehensive, Agencywide space environment and effects program. Completion of the LDEF data analysis is scheduled for FY 1995. Protective coatings for atomic-oxygen sensitive polymers have been developed and demonstrated. Newly-developed structural ceramic ablator shows improved ablation performance compared to traditional materials. Space structures research developed erectable truss hardware which was demonstrated on orbit and assisted the INTELSAT retrieval; two high-performance, low-weight shields were developed which provide the same protection level with 50 percent weight savings; and, extravehicular activity (EVA) assembly procedures for a precision reflector were verified in neutral buoyancy.

Areas addressed by the Information and Controls program include computer science, sensors, photonics, controls, guidance, automation and robotics, and human factors. In the computer science area, the thrusts of the research program includes access to and management of very large scientific data sets and real time hardware and software for the Kennedy Space Center (KSC) Orbiter Processor Facility shop floor automated system; software engineering tools for generation of very complex and reliable software; and innovative and highly effective computation approaches emphasizing non-linear fuzzy logic controls. The primary objective of the photonics research is to develop advanced opto-electronic components and system concepts and to implement a high-speed optical sensor and sensing and electronic devices for high energy science observation missions. In the controls area, the goal is to reduce by orders of magnitude the size of guidance and controls components for micro-spacecraft. In automation and robotics, research will continue to concentrate on advanced sensors and mechanisms to support telerobotics vehicle health management and the development of advanced artificial intelligent concepts applicable to the problems of critical interest to the country. Progress continues to be made in the development of a set of techniques which collectively are called virtual interactive environment workstation or artificial reality. A data base for virtual exploration of the Mars surface and an Earth-analog environment has been established.

The Space Communications program focuses on the development of critical high risk devices, components, and analytical methods in support of NASA missions, U.S. commercial satellite communications industry, and other government agencies. The program contributes to the preservation of U.S. preeminence in satellite communications technology. The advanced research focuses on the areas of microwave and millimeter-wave devices, digital systems development, optical communications and mobile communications systems. The goal is to develop enabling technologies which are bandwidth and power efficient, have extended lifetimes, and are low in weight and volume. In the radio frequency technology area, continuing advancements in antennas, satellite switching, low noise receivers, high power amplifiers are being achieved. State-of-the-art performance was demonstrated in a high efficiency, Ka-band traveling wave tube amplifier capable of operating in the deep space environment; radio frequency power and efficiency have been increased by a factor of two. The digital systems technology focuses on the development of high speed modems and codes, information and switching processors, and autonomous network control; extensive use of in-house computer-aided design facilities are utilized for microprocessor, expert system and neural network applications. The primary objective of the optical communications research is to develop the integrated technologies required to develop optical transceiver systems for satellite laser crosslinks. The unique accomplishments during FY 1992 were the completion of mobile terminal design and design review, completed fabrication of a 220 MBS optical communications receiver, and the completed construction of a Ka-band small reflector antenna.

In the Human Support program, extravehicular operations by astronauts will be aided by a new technology in a high-pressure extravehicular glove design and new thermal control methods for life support. For environmental control and life support systems, the goal is to provide a technology base in chemical processing techniques to support future human space missions. Closed-loop life support chemical processing technologies will provide recycled air and water for crew consumption to eliminate or significantly reduce mission resupply requirements. In FY 1993, increased emphasis was placed upon developing a fully integrated

life support system from various component technologies for air, water, and waste processors, including chemical and microbial sensors and integrated system controls to assure safe operation and safe human consumption of recycled air and water. In this first year of life support sensor technology development, progress has been made in producing selected micro-sensor elements capable of detecting individual chemical and microbial species which may be present in recycled air and water systems. An integrated life support system testbed utilizing existing field center facilities was also initiated which will incorporate both sensor and process control technologies to achieve safe, reliable operation and characterization of closed life support systems.

The purpose of the In-Space Technology Experiments program and the Space Flight Research and Technology program is to support flight validation of innovative technologies developed in ground-based programs and to facilitate the transfer of technology from NASA, universities or industry to NASA or commercial flight programs. In June 1992, the Environmental Verification Experiment was launched on the Extreme Ultraviolet Explorer (EUVE) spacecraft. This experiment has been returning data for six months on the space environment around the spacecraft. Analysis of the data will enable the updating of existing environmental models to be used in the design of advanced, more efficient spacecraft. Other accomplishments include flight of the Orbital Acceleration Research Experiment (OARE) in June 1992 as part of the Orbiter Experiments program (OEX). The OEX started with the first Shuttle flight (STS-1) utilizing Columbia as a research vehicle to characterize aerodynamic and aerothermodynamic performance of the Shuttle. The data collected over the years by the 12 OEX experiments have been an important source for designing and developing performance improvements in the present orbiter program and have supplied data for validating models for the design of future space transportation vehicles. As part of OEX, OARE collected and returned orbital and re-entry acceleration data from the STS-50 flight in June 1992 of the Space Shuttle Columbia.

To facilitate the design of advanced thermal management systems for spacecraft, two heat pipe experiments were launched on the Shuttle in October and December 1992 respectively. These experiments have tested the performance characteristics of heat pipes of various designs and materials. The results have contributed considerably to the engineering data base needed for the design of highly efficient and reliable thermal systems in space. Experiments to complete this data base are planned for the future. Also in October 1992, the second flight of the Tank Pressure Control Experiment was accomplished onboard the Shuttle. This time the experiment focused on collecting data on thermal phenomena which are needed for the design of advanced cryogenic tanks. During FY 1993, the hardware development of seven experiments will be completed and readied for launch in FY 1994. In addition, approximately fifty new experiments will be selected for feasibility study from the 345 proposals received in response to the Announcement of Opportunity issued in November 1992. These new experiments are expected to be ready for launch starting in late 1995. They will be flown on the Shuttle, expendable launch vehicles, and the Space Station.

The objective and structure of the Systems Analysis program were revised in FY 1993 to focus on key space system issues as well as to identify critical technologies for future space missions for NASA, DOD, and commercial missions. The results of these studies will be used directly to formulate and/or redirect the Space Technology program to address and provide critically needed technologies for both government and industry needs. The program has been consolidated and assigned to three field centers, each focusing on a specific area of systems analysis and technology identification, in concert with U.S. space program goals and objectives. At Langley Research Center (LaRC), the systems analysis focus will be on new transportation systems that identifies technology requirements for competitive launch systems for the U.S. At Lewis Research Center (LeRC) systems analysts efforts are studying the benefits of nuclear propulsion systems for future space missions, including the required pacing technologies to enable future transportation systems. The Jet Propulsion Laboratory (JPL)'s role in the Systems Analysis program is to conduct the necessary studies and technology trades for future science spacecraft and/or platforms. FY 1993 accomplishments include the restructuring of this vital program, the concept definition and technology options for a single-stage-to-orbit advanced manned launch system, and a benchmark assessment of two-stage-to-orbit advanced manned launch system. The identification of system level issues and technology options offering optimum small/micro-spacecraft system performance will also be completed in FY 1993. These planned accomplishments will be utilized to direct and focus the entire Space Technology program as appropriate space systems and technologies are identified.

The objective of the University Space Research program is to enhance and broaden the capabilities of the Nations's engineering community to participate more effectively in the U.S. civil space program. This program is an integral part of the strategy to strengthen the Nation's space research and technology base. The program elements include the University Space Engineering Research Center program, which supports interdisciplinary research centers at selected universities and the University Advanced Space Design program, which funds senior level advanced systems study courses. In FY 1992, a third element of the university program, the University Innovative Research program, which provided grants to individuals with outstanding credentials, was completed. High priority, user-oriented research previously funded by this program will be supported by the appropriate Base R&T program. Also in FY 1992, a comprehensive peer review of all nine university space engineering research centers was conducted to obtain peer reviews of progress, measured against the original program objectives, and to obtain recommendations concerning the future of each center. As a result of this peer review process, the centers received very strong recommendations for continuation. One center was not continued beyond FY 1992. Significant technical accomplishments are emanating from these centers. For example, antiprotons, injected at peak compression of uranium-hydrogen, have been demonstrated to trigger microfission in subcritical experiments for inertial fusion propulsion; high performance Very Large Systems Integration Reed Soloman processor have been developed and delivered to NASA, the only certified decoder capable of operating at the Tracking and Data Relay Satellite (TDRS) rates; developed miniature micro-flow sensor and technique for bonding to almost any substrate; developed the first 250 GHz planor monolithic receiver. These centers are attracting, retaining, and training a unique multidisciplinary cadre of graduate students and attracting increased industry support.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Space Research and Technology Base reflects a decrease of 15.7 million. This is the net result of the distribution of the appropriations general reduction of $18.5 million, the reallocation of $5.1 million of hypersonic research funding to the aeronautics research and technology base, the reallocation of $0.1 million to Research Operations Support (ROS) in the Aeronautical Research and Technology budget offset by the transfer of $8.0 million due to the redistribution of the ROS funding. The reduction directed by Congress impacts planned activities within the NASA field centers as well as universities and industry.

The reductions/changes by discipline program are as follows:

Aerothermodynamics Research and Technology has been reduced by a total of $4.0 million. This consists of the net effect of $1.2 million hypersonic funding reallocated to the aeronautics research and technology base, a $4.3 million reduction to accommodate the Congressionally-directed reduction which was accomplished by eliminating overlap and duplication in field center efforts and by eliminating specific research tasks associated with exploration missions, offset by the transfer of $1.5 million due to the redistribution of ROS funding.

The Space Energy Conversion Research and Technology program has been reduced by a total of $1.8 million which reflects a net effect of a reduction of $2.6 million as part of the Congressional reduction which was achieved by consolidation of thermal management research activities at one field center, a decrease in photovoltaic research and a phase out of the alkalai metal thermal to electric conversion (AMTEC) technology, offset by the transfer of $0.8 million due to the redistribution of ROS funding.

The Propulsion Research and Technology was reduced by a total of $1.8 million which is the net effect of a $2.6 million Congressional reduction offset by the transfer of $0.8 million due to the redistribution of ROS funding. The impact of this reduction was to eliminate propulsion and related research activities applicable to exploration missions. Research efforts in advanced propulsion concepts were also consolidated to one field center.

Materials and Structures Research and Technology has sustained a total reduction of $2.5 million. This includes $3.2 million of hypersonic funding reallocated to the Aeronautics Research and Technology base, a general reduction of $0.5 million offset by the transfer of $1.2 million due to the redistribution of ROS funding.

Space Flight Research and Technology reflects a net reduction of $3.3 million, which consists of a Congressional reduction of $1.2 million, a realignment of $2.5 million to the In-Space Technology Experiments program to enhance industry/university experiments, offset by the transfer of $0.4 million due to the redistribution of ROS funding. This reduction resulted in the postponement of the Modal Identification Experiment (MIE) and will significantly reduce the number of new experiment proposals to be funded for Phase A studies.

The Systems Analysis program has increased by $0.2 million, which is the net effect of $0.4 million of hypersonic research and technology funding reallocated to the Aeronautics Research and Technology base offset by the transfer of $0.6 million due to the redistribution of ROS funding.

The University Space Research program has not changed.

Information and controls research and technology has been reduced by $3.8 million. This is the result of a Congressional reduction of $4.0 million with impacts in such areas as controls technology, data management, and software verification efforts. In addition, $0.3 million hypersonic research and technology funding was reallocated to the Aeronautics Research and Technology base offset by the transfer of $0.5 million due to the redistribution of ROS funding.

Human support research and technology reflects a net increase of $1.1 million. This is a result of a transfer of $1.0 million due to the redistribution of ROS funding and a $0.1 million increase for human factors engineering activities.

The Space Communications Research and Technology program received a total reduction of $2.3 million, which includes $3.2 million as part of the Congressional reduction, $0.1 million which was reallocated to the ROS in the Aeronautics program, offset by transfer of $1.0 million due to the redistribution of ROS funding.

The In-Space Technology Experiments program increase of $2.5 million is the result of a Congressional reduction of $0.2 million, offset by a realignment of $2.5 million from space flight research and technology to enhance industry/university involvement in this program, and $0.2 million due to the redistribution of ROS funding. The realignment allowed the hardware development of existing industry and university experiments to stay on schedule and allowed the solicitation of new proposals for experiments to be carried out by graduate students in the aerospace engineering disciplines.

BASIS OF FY 1994 ESTIMATE

The Aerothermodynamics program supports the development and application of analytical and experimental capabilities to understand the complex, hypervelocity flow environment in which a vehicle operates during ascent, entry, and maneuvering in the Earth and other planetary atmospheres. The program also includes the conduct of analytical and experimental research to advance the technology of vehicle design for aerothermodynamic efficiency. Program emphasis in FY 1994 will center on concepts for advanced manned launch systems re-entry vehicle design analysis and experimental verification and on developing an improved understanding of chemical and radiative nonequilibrium flow phenomena and on low density flows. This physical understanding is critical to improving the computational design tools necessary to reduce vehicle design risk and uncertainties.

In FY 1994, the Space Energy Conversion program will continue technology development that will meet the needs of next-generation spacecraft, both government and commercial. Demonstration of long-lived, advanced common pressure vessel and bipolar Ni-H2 batteries and regenerative fuel cell storage systems for potential upgrades for space platforms will also be under way. Thermovoltaic power converters and alkali metal thermoelectric conversion systems aimed at deep space science applications will have been demonstrated. Integrated, environmentally durable, photovoltaics/battery/power management systems combined with electric propulsion for near-Earth space applications, including commercial satellites and Earth observing satellites, will be defined and technology programs with industry will be initiated. A joint effort with industry to insert electromechanical actuators for thrust vector control in commercial launch vehicles will be near completion. Power integrated circuits that substantially reduce parts count and size while increasing reliability and performance in deep space vehicles will be transitioning to flight. A program to produce wide temperature range electronics that will benefit deep space missions where extreme temperatures are encountered will yield products with additional applicability to both aeronautics and automotive applications.

In FY 1994, the Propulsion program will continue to conduct and support technology development and insertion efforts critical to the maintenance of U.S. competitiveness in the space propulsion arena. Some of the significant technical milestones which will be achieved are the validation of ''zero-g'' water vaporizer concepts on orbiter-tended propulsion systems, validation of structural integrity of a 8kg/5kW class ion thrusters for repositioning and planetary applications, and the demonstration of Earth and space storable engines capable of achieving 330-345 seconds of specific impulse for apogee and planetary applications.

The Materials and Structures program will continue to focus on extended space durability and environmental effects, lightweight structures for space systems, and technology to enable the development of large space structures. Continued evaluation of materials and coating systems from the Long-Duration Exposure Facility (LDEF) will provide a baseline for assessing stability and long-term durability of materials, coatings, solar cells and other related space systems in both low-Earth orbit and geosynchronous Earth orbit. Individual and synergistic space environmental effects (such as radiation and atomic oxygen effects) on materials will be assessed using degradation models to describe environmental interaction. Computational chemistry will be used to develop data bases for properties of polymers and to model material interaction phenomena on the molecular level. Advanced materials development will focus on very high temperature ceramic matrix composites for thermal protection systems.

Advanced materials and structural concepts will be explored for integral cryogenic tanks and thermal protection systems, including advanced metallic and composite cryogenic tank concepts and durable, woven ceramic thermal protection systems, for future space vehicles. Reusable rigid insulation systems for 3000+^{o}F performance will be demonstrated. Design concepts, design tools, lubrication methods and accelerated test procedures for reliable, long-lived space mechanisms will be developed. Space environment data and effects on materials and space systems will be developed, which will result in more resistant and durable

materials and material systems, such as films and coatings. Progress will be made toward developing advanced materials, fabrication and structures technology to reduce cost and improve the performance and reliability of future launch vehicles; and support for advanced concepts of optimization and sensitivity analysis which will be combined with disciplinary analysis methods for efficient synthesis methodology applicable to Space Station of space structures and antennas. In FY 1994, smart materials and adaptive structures will be explored to tap the potential of this technology in adapting, controlling, pointing, and vibration reduction of interferometer-like structures, space platforms for Earth or space observations, and long truss-like structures for space observations or support structures.

The Information and Controls program supports applied research in computer science, sensors, photonics, controls, guidance, automation, and robotics. In the computer science area, the focus is on access to and management of very large scientific data sets; software technology transfer to improve Shuttle operations; software engineering tools for generating very complex and very reliable software; and innovative, but potentially highly effective, computational approaches such as fuzzy logic controls. Sensor research will continue to concentrate on development of solid-state laser materials for enhanced atmospheric science, ranging and altimetry, and other remote sensing applications. Photonic research will emphasize device development in opto-electronic integrated circuit technology for spaceborne systems, such as autonomous landing and optical computing and sensor and processor technology transfer for Space Shuttle Main Engine (SSME) testbed plume analysis. Artificial intelligence efforts will include machine learning, distributed diagnostic systems capable of model-based, as well as experimental reasoning, and embedded real-time systems for scheduling, control and diagnostics. In telerobotics, the program will support academic research on mobile planetary robotic systems, micro-rovers, free-flying telerobotics systems and multiple interactive robotic systems. In the controls and guidance area, emphasis is being placed on the development of analytical tools for the design of control systems for precision pointing and control sensors and actuators for micro-spacecraft and for avionics systems technology for advanced transportation vehicles. Human factors research will continue development of new technology to model and enhance human performance. Models and data on physical and cognitive capabilities in microgravity will be emphasized. Particular focus will be placed on new methods of presenting visual information via computer-based displays and technology to visualize virtual environments for planetary surface applications.

The Space Communications program will be directed toward NASA and commercial satellite communications needs. This program supports applied research and advanced developments in the areas of digital technology, optical communications and radio frequency communications, and module communications systems. The digital technology area emphasizes research on modulation, coding, and switching up to 1 gigabit per second. The optical communications area is advancing the state-of-the-art in laser transceivers for free-space optical communications. The radio frequency communications area is performing research on high-efficiency monolithic millimeter-wave circuit technology on high-performance electron beam technology for advanced deep-space and satellite communications. In FY 1994 the first Ka-band mobile communications terminal will be completed. The terminal will be used to demonstrate the potential of Ka-band communications for space to ground links.

In the Human Support program, research will continue on developing the first fully integrated, closed life support system capable of providing air and water for human consumption during space missions utilizing wastes generated from human metabolic processes and other onboard processes. Sensor research will continue to develop and produce chemical sensors and microbial sensors for utilization in the component and system level control system. Specific requirements for, and development of these control systems will also be initiated in FY 1994. Research to establish new concepts and develop effective chemical processors which will convert waste products into consumable air and water will also be initiated.

In FY 1993, the In-Space Technology Experiments (IN-STEP) program was transferred into the research and technology base. This transfer has resulted in more flexibility in determining experiment feasibility, definition, and development of the hardware/software for the space validation of new technologies. The experiments in this program will continue to provide flight validation of technologies developed in industry or universities, while the continuation of the Space Flight Research and Technology program provides for technologies developed in the NASA centers and the Jet Propulsion Laboratory (JPL). In FY 1994, both programs will continue the flight testing of enabling and enhancing technologies which require the actual space environment for validation. Flight data obtained from in-space research and experimentation will be used to validate and update analytical models, prediction techniques and ground test methods. The program activities support the identification, definition, design, fabrication and flight certification of future in-space experiments which will use the Space Shuttle, expendable launch vehicles and Space Station as platforms.

Specific milestones for FY 1994 will include the launch of five small experiments on a common Hitchhiker carrier in the Shuttle bay. This will support the measurement of the spacecraft glow phenomena, the collection of data on the freeze-thaw behavior of molten salts (which are needed for the design of thermal energy storage systems), the validation of a water electrolyzer in space, the measurement of solar cell arcing under high voltage conditions and an advanced space radiation measurement device. Results of these experiments will serve to aid in the design of space platforms and other spacecraft. The Lidar In-Space Technology Experiment (LITE) will be launched verifying the technology readiness of using a Lidar, including a solid state laser, in space for observing critical atmospheric conditions. The feasibility studies of the approximately fifty experiments selected in FY 1993 will have been completed and the most promising of these experiments will be selected to continue into the definition and preliminary design phase.

The Systems Analysis program supports the development of analytic tools and data bases required to perform engineering tradeoff studies in order to prioritize and integrate multidisciplinary sets of technology options. This effort is closely coordinated with the spaceflight mission program offices to identify the technology requirements for their future mission concepts and technology opportunities for enabling new and improved future missions. In FY 1994, the emphasis of the transportation systems effort will be on launch vehicle concept design studies to assess technologies for the next generation of manned launch vehicles and nuclear electric propulsion for cargo and piloted space transfer vehicles. Technology options to be studied

address staged and single-stage-to-orbit vehicles, horizontal and vertical takeoff and landing vehicles, rocket and airbreathing vehicles, and combined engine concepts. For spacecraft systems, efforts will focus on conducting studies on technologies for the next generation of astrophysics observatories, understanding the potential of miniature spacecraft and micro-science instruments for future Earth and planetary science, and studying the critical technologies necessary for enabling the projected data rates of future science missions.

The University Space Research program is to enhance and broaden the capabilities of the Nations's engineering community to participate more effectively in the U.S. civil space program. In FY 1994, support will continue for the two program elements: the University Advanced Space Design program, which funds advanced systems study courses at the senior level; and the University Space Engineering Research Center program, which supports interdisciplinary research centers. In FY 1994, emphasis will be on maintaining the eight incumbent university space engineering research centers at their planned funding level and encouraging efforts to increase non-NASA funding support and interactions.

BASIS OF FY 1994 FUNDING REQUIREMENT

CIVIL SPACE TECHNOLOGY INITIATIVE (CSTI) PROGRAM

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Operations	36,848	--	--	--
Transportation	27,754	--	--	--
Science	18,346	--	--	--
Space science technology	--	36,700	17,308	33,900
Planetary surface technology	--	22,000	17,314	3,200
Transportation technology	--	42,400	29,085	36,400
Space platforms technology	--	24,600	26,928	23,700
Operations technology	--	32,500	23,981	40,200
Total	82,948	158,200	114,616	137,400

OBJECTIVES AND STATUS

In FY 1993, the CSTI program was restructured to more clearly address the technology needs for high priority civil space missions to focus on research in five thrust areas: space science, planetary surface, transportation, space platforms, and operations. The CSTI program will support many critical technology efforts that are essential to accomplishing our future space goals and will contribute to ensuring U.S. preeminence in research and technology. The following discusses the CSTI program thrusts.

The space science technology thrust is providing technology for future space science missions. The science sensing area consists of three elements: direct detectors, submillimeter sensing, and laser sensing. The observatory systems area consists of two elements: coolers and cryogenics, and micro-precision controls/structure integration. These technologies have application to the Earth Observing System (EOS) and future candidate missions in astrophysics, space physics, and other disciplines. Infrared detector arrays are critical for a variety of space science applications including observations of the Earth's surface and atmosphere, highly sensitive observations of stars and interstellar dust clouds, and broadband observations of the infrared portion of the sun's spectrum. To meet these observation needs, the direct detector element has developed a number of promising technologies to the point where they can be thoroughly evaluated.

and the most promising approaches selected for further development. Submillimeter wavelength observations are used to identify the chemical make-up of the upper atmosphere of the Earth, as well as interstellar gas clouds. Previous technology efforts led to the 205 GHz instrument currently flying on the Upper Atmosphere Research Satellite (UARS) which is observing gasses critical to the Earth's ozone cycle, and the ground-based testing of instruments at frequencies up to 600 GHz. Space-based lasers provide the best approach to provide the global measurements of the Earth's winds, a critical measurement to improve climate modeling and weather prediction. Previous laser sensing element efforts have led to the breadboard demonstration of carbon dioxide gas lasers for the EOS Laser Atmospheric Wind Sounder (LAWS). Recent efforts have demonstrated several promising, solid-state lasers that could reduce the size and complexity of the LAWS instrument. These solid-state lasers will be evaluated on a solid-state Doppler lidar test-bed. Many sensitive science instruments require mechanical cooling to reduce noise and increase mission life. The coolers and cryogenics element has developed two competing designs for two-stage, Stirling cycle mechanical coolers that will provide cooling to 30 degrees Kelvin. These designs will be built, tested, and evaluated. In addition, several control approaches have been demonstrated that reduce the vibration of current, single-stage coolers. Many science missions require highly precise, vibration-free structures to obtain the required measurements. The Micro-Precision Controls/Structure Integration program is developing the techniques for the design and development of these structures. Although the focus is on optical systems (both filled apertures and interferometers), these techniques have application to other missions such as low vibration, microgravity missions. Optical modeling developed under this program was used to evaluate the "prescription" needed for the Hubble Space Telescope (HST) repair mission, and precision actuator technology developed by this program has been selected for use in the HST repair mission. In addition, this element has demonstrated on a ground test-bed a unique, three-layer control approach to provide highly stable optical paths for space structures.

The planetary surface technology thrust includes programs that are essential for robotic and human exploration of the solar system. In FY 1993, work was begun to develop a microrover to be carried on the proposed MESUR Pathfinder mission to Mars. This activity has developed a complete set of design requirements and identified and assessed many of the components needed for the rover. The rover design is based on the Rocky IV rover which was modified and extensively tested by the Jet Propulsion Laboratory (JPL) this year. Two major milestones in FY 1993 will be a preliminary design review and a non-advocate review currently scheduled for the third quarter. Work also continued on developing technology for space nuclear power systems. In FY 1992, a complete 12.5 kWe Stirling cycle power conversion system was fabricated for operation at 950° K. Initial testing in FY 1993 has shown this system to perform to specifications. Fabrication of a long-term test system will be completed in FY 1993 for operation at 1050° K, the design condition for use with an SP-100 space nuclear reactor power system. In FY 1993, NASA will work with the Department of Energy on the SP-100 program. During FY 1992, a major accomplishment was demonstrating the operation of an engineering model of the thermoelectromagnetic primary coolant pump and verifying the compatibility of the coolant loop with liquid lithium coolant.

The transportation technology thrust is primarily concerned with providing the technology needed for future major transportation improvements. The overall goal of the transportation technology thrust is to develop and validate technologies that will substantially improve safety margins and reliability, increase system availability, reduce life-cycle costs, and provide new capabilities for current and future space transportation vehicle systems. In FY 1993, additional emphasis is being placed on facilitating the transfer of these emerging technologies to the commercial space sector through cooperative activities with industry. The transportation thrust consists of two major areas: (1) Earth-to-orbit (ETO) technology and (2) space transportation technology. The ETO area includes research on propulsion system component and subsystem technologies, integrated health monitoring/condition monitoring technologies, design tools, and low-cost manufacturing processes for the next generation of expendable and reusable space transportation systems. Significant technical accomplishments in FY 1992 included in the ETO area include: demonstration of casting technology for a one piece main combustion chamber (MCC) and fabrication technology for a low-cost cooling liner; and adoption of an optical plume analyzer on the Stennis test stands and the testing of an advanced ceramic bearing system that meets the original Shuttle engine goals which are approximately 20 times that which is currently being realized with the existing bearings. In cooperation with industry a small scale version of a low cost fuel injector and improved bearing system were tested at the Lewis Research Center (LeRC). In FY 1993 tests of a larger combustion unit with the low-cost injector and a prototype turbopump with the improved bearings will be tested at the LeRC and Stennis Space Center (SSC), respectively. The space transportation area also incorporates two space propulsion elements: space-based engines and nuclear thermal propulsion. This research includes validating system-level technology for moderate-thrust, expander cycle liquid oxygen/liquid hydrogen chemical engines. The goal is to provide the technology base for the next generation of high-performance upper stage engines. Technology for high-power nuclear thermal propulsion systems which could substantially reduce the mass required in low-Earth orbit and substantially reduce the trip time associated with exploration missions will be reduced to include only systems trade studies.

The space platforms technology thrust is primarily concerned with providing the technology needed for future space platforms. This thrust seeks to provide technologies for the following mission classes: unmanned Earth orbiting platforms in low-Earth orbit or geosynchronous Earth orbit (including technology transfer to commercial satellites), manned Earth orbiting platforms, and deep-space platforms. The goals of this thrust are to enable reductions in launched weight through spacecraft mass reductions, increased spacecraft lifetimes, increased maintainability, and decreased logistics resupply needs. The achievement of these goals will enhance the performance of both government and commercial spacecraft. Ongoing efforts include the Platform Structures and Dynamics program, previously supported by the Control/Structures Integration (CSI) program, and the Solar Dynamics program. The platform structures and dynamics effort is focused on advancing state-of-the-art technologies to enable the precision control of future space structures that support sensitive science instruments. Another goal of this program is to focus on the control requirements

of future manned space platforms. The Solar Dynamics program is working toward the ground demonstration of a 2 kilowatt integrated solar dynamic system. An initiative begun in FY 1993 provides support for advanced technology insertion into the early planning for the Pluto Fast Flyby Mission and the first Earth probe missions in order to reduce cost and schedule while greatly enhancing performance. In FY 1992, the CSI benefits study for advanced Earth observing spacecraft was completed with identification of a number of important benefits to these spacecraft. Closed-loop testing of the CSI controllers on the Space Shuttle Manipulator Arm was successfully completed. The solar dynamic group test program began in FY 1992 with a successful completion of the system requirements review and the awarding of the contract for the test hardware. In FY 1993 advanced spacecraft hardware (sensors, structures) and software will be assembled for the preliminary design phase of future missions such as the Pluto Fast Flying and the Thermosphere, Ionosphere, Meosphere Evergetic and Dynamics (TIMED) Earth probe missions.

The goal of the operations technology thrust is to develop and validate technologies to reduce the cost of NASA operations, improve the safety and reliability of those operations and enable new, more complex, activities to be undertaken. For the ongoing FY 1993 program, specific program areas include two elements: (1) automation and robotics and (2) information and communications. The automation and robotics area will develop artificial intelligence systems to support mission operations and expert data analysis. In FY 1992, the introductions of advanced scheduling technology has significantly improved the ability to schedule Shuttle processing, while saving hundreds of thousands of dollars for each launch. Operation of the SKYCAT program enabled cataloging of the Palomar Sky Survey two orders of magnitude faster than previous techniques. In early FY 1993, the Dante and Rocky IV robotic vehicles were developed and demonstrated, with Dante being deployed to the Antarctic in December 1992. The program also addresses long-term issues associated with control of multiple knowledge-based systems, the management of uncertainty in complex systems, and machine learning. In addition, this area will evaluate robotics systems to support both ground processing and in-space activities. Telerobotic devices to perform a number of inspection tasks required for Shuttle processing will be developed. Also, demonstration of ground-based models of in-space activities for future application to telerobotics tasks will be supported. The information and communications area addresses the high-priority needs across NASA for more capable space processors and systems, more effective software development, and advanced communications capabilities. In particular, the program will concentrate on space-qualifiable computers, special processors, and memory systems, and will investigate architectures to support space data systems. In FY 1993, data compression techniques and chips were transferred to both space and commercial applications, and characterization of space computers led to the selection of onboard computers for the Cassini mission.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The total FY 1993 CSTI budget was reduced $43.6 million, which is the net result of a Congressional reduction of $46.5 million partially offset by a transfer of $2.9 million due to the redistribution of Research Operations Support (ROS) funding. Support for research activities, some of which are already

funded at a marginal level, will be confined to addressing only a few of the high priority user office needs. Many technology tasks planned for FY 1993 will be eliminated or deferred. Changes by technology thrust are as follows:

Space Science Technology

The Space Science Technology program reflects a net decrease of $19.4 million which reflects a decrease of $19.7 million to accommodate the Congressionally-directed reduction and a transfer of $0.3 million due to the redistribution of ROS funding. Reductions in science sensing total $11.6 million and reductions in observatory systems activities total $8.1 million, offset by ROS transfers of $0.3 million. This significantly reduces planned activities in microprecision controls and structures interaction, as well as research efforts in high-energy detector technology, laser metrology, and coolers and cryogenics.

Planetary Surface Technology

In planetary surface technology, the net reduction of $4.7 million, which is the net result of $5.0 million Congressional reduction and $0.3 million ROS transfer. This will result in the termination of all focused research efforts in human support technology ($7.0 million). Within planetary surface technology funding has been redirected to initiate studies leading to development of a rover to be flown on the MESUR/Pathfinder mission ($2.0 million). This rover will be instrumented to conduct technology experiments in mobility navigation and system integration for science data collection.

Transportation Technology

Transportation technology has been reduced by a total of $13.3 million, which is the net result of $14.8 million Congressional reduction, partially offset by a transfer of $1.5 million due to the redistribution of ROS funding. This net reduction has been accommodated by reducing Earth-to-orbit transportation by $9.0 million and space transportation technology efforts by $4.3 million.

Space Platforms Technology

In space platforms technology, funding has been increased by $2.3 million. Funding for technology efforts in platform structures and dynamics has been reduced by $6.0 million and platform power and thermal systems has been decreased by $2.0 million. These reductions have been offset by increased funding to initiate analytical and experimental efforts toward innovative concepts in lightweight planetary spacecraft ($5.0 million) and Earth observing spacecraft ($5.0 million) and a transfer of $0.3 million due to the redistribution of ROS funding.

Operations Technology

Operations technology funding has been reduced by a total of $8.5 million, which is the net result of $9.0 million Congressional reduction, partially offset by a transfer of $0.5 million due to the redistribution of ROS funding. This will be accommodated by a reduction of $3.1 million in automation and robotics and $5.4 million in space data systems and will include termination of the development of the spaceflight optical disk recorder.

BASIS OF FY 1994 ESTIMATE

In the space science technology thrust for FY 1994, the direct detector element activities will continue the development of large area, 65 degree Kelvin operating temperature detector arrays in the 12- to 18-micron region of the electromagnetic spectrum, pursuing the three most promising approaches developed in FY 1993. In addition, this element will develop highly sensitive, low operating temperature arrays in the 30- to 300-microns region using blocked impurity band phenomena. The submillimeter element will provide the initial laboratory demonstration of a heterodyne receiver system operating near 800 GHz for astrophysics mission applications. The laser element will complete the development a ground test-bed to demonstrate solid-state Doppler lidar for wind measurements, and will continue developing solid-state lasers for evaluation on the test-bed. The coolers and cryogenics element will complete the brass-board model of the two-stage, 30° Kelvin Stirling cycle cooler, and will begin environmental testing of this cooler. The micro-precision controls/structure integration element will complete phase one of the micro-precision interferometer testbed, as well as the design of a 6-axis isolation system, leading to the demonstration in FY 1995 of vibration attenuation to the sub-micron level.

In FY 1994 the planetary surface technology program will focus on developing technologies primarily in support of robotic science missions. Specifically, a program will be initiated to develop advanced rover technology to further support the needs for advanced science rover technology. In FY 1994 this effort will focus on issues such as advanced mobility systems, autonomous navigation and systems integration. The joint NASA/Department of Energy (DOE) SP-100 program will be terminated at the end of FY 1993.

The transportation technology thrust is concerned with providing the technology needed for future transportation systems. The overall goal of the transportation technology thrust is to develop and validate, through industry/government/academic partnerships, innovative technologies that will provide new capabilities and will enable the development of future space transportation systems with reduced life-cycle costs, substantially improved safety margins and reliability, and increased system availability, ensuring U.S. commercial competitiveness and world leadership in exploration and utilization of space. In FY 1994, additional emphasis will continue to be placed on cooperative activities with the expendable launch vehicle industry. Significant FY 1994 milestones include: (1) a large scale firing of an integrated cast chamber/cooling liner main combustion chamber (MCC) which builds upon FY 1993 plans to fabricate several

integrated cast chamber/cooling liner MCC's for testing and evaluation. This technology is projected to lead to a seven-fold reduction in fabrication costs, a reduction in MCC welds from 96 to 4 and reduction in fabrication time from approximately three years to six months and (2) if FY 1993 tests of a larger combustion unit with the low-cost injector and a prototype turbopump with the improved bearings at the LeRC and SSC are successful. FY 1994 plans include consideration of large scale testing on complete system employing both of these, as well as other technology advances, using both cryogenic (Hydrogen/Oxygen) and hydrocarbon fuels.

In the <u>space platforms technology</u> thrust, platform structures and dynamics will focus on developing and applying controls/structures integration techniques to space platforms and to developing advanced platform structures concepts. Ground-based hardware testbeds, including both in-house and non-NASA guest investigator activities, will continue to be supported. In FY 1994, laboratory experiments will be completed on the simultaneous pointing of multiple, independent science sensors using a platform-like ground test bed. Also, the ground test bed of a space station pre-integrated truss will be completed and modal testing will begin. The platform power and thermal systems will focus on developing and demonstrating key technologies for increased power at reduced costs for future Earth-orbiting spacecraft, low-Earth orbit (LEO), or geostationary Earth orbit (GEO) science spacecraft, and future astrophysics missions. In FY 1994, the fabrication and testing of the components of the solar dynamic ground test system will be completed and installation of the system will be initiated. The Advanced Technology Insertion program for the Pluto Fast Flyby and TIMED science missions will continue with the initial fabrication of testbeds to check out advanced instrument and platform technologies. These testbeds will permit the selection of the best advanced technologies that will enable fabrication of lighter weight, lower cost spacecraft.

In the <u>operations technology</u> thrust, the FY 1994 program will focus on supporting automation and robotics and space data systems. The automation and robotics portion will focus on advanced teleoperation, robotics and supervisory control (telerobotics) to be applied to problems in launch processing, on-orbit operations and processing, and science operations. During FY 1994, the program will demonstrate robotic inspection capabilities with contact and manipulation; demonstrate an intra-vehicular activity (IVA) robot with collision avoidance; and demonstrate spacecraft repair with communications time delay. The artificial intelligence program will focus on providing real-time, fault-tolerant control for flight critical systems and on developing, testing and validating increasingly complex autonomous systems. This will start with automation of a single critical function and progressing to coordinated control of multiple critical functions. This includes increasingly productive assistance to mission operations, moving from single function applications toward multiple, cooperating applications, automated engineering analysis tools, autonomous onboard diagnostic systems, and life-cycle knowledge capture systems. The intelligent aid named PI-in-a-Box is scheduled to fly on the Shuttle in October 1993 and in 1994 a prototype diagnostic and control system for the Advanced X-ray Astrophysics Facility (AXAF) will be demonstrated. The space data

systems efforts will continue to focus on developing and demonstrating new onboard processing and data storage capabilities for a range of future space and Earth science, exploration and infrastructure systems. Preliminary design of experimental onboard digital processors and correlators will be continued. The program is working towards demonstration of a high speed gallium arsenide pipeline processor in FY 1995, and a multi-channel 500 MH_2 auto correlation spectrometer will be tested during FY 1994.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

COMMERCIAL PROGRAMS

		1993			
	1992 Actual	Budget Estimate	Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Technology transfer....................	32,500	31,700	29,495	26,900	RD 8-2
Commercial use of space................	115,100	139,900	134,879	145,100	RD 8-7
Total...........................	147,600	171,600	164,374	172,000	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY — TECHNOLOGY TRANSFER

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Civil systems	13,000	6,500	6,500	3,400
Dissemination	5,800	5,900	4,695	5,600
Network	6,500	9,500	9,500	9,000
Applications	7,200	9,800	8,800	8,900
Total	32,500	31,700	29,495	26,900

Distribution of Program Amount by Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Johnson Space Center	4,546	2,380	2,495	905
Kennedy Space Center	320	425	380	560
Marshall Space Flight Center	970	877	1,000	1,483
Stennis Space Center	750	570	785	635
Goddard Space Flight Center	1,452	1,460	1,298	1,775
Jet Propulsion Laboratory	640	600	675	925
Ames Research Center	763	412	1,225	1,045
Langley Research Center	1,083	620	527	996
Lewis Research Center	775	716	880	1,205
Headquarters	21,201	23,640	20,230	17,371
Total	32,500	31,700	29,495	26,900

OBJECTIVES AND JUSTIFICATION

The NASA Technology Transfer program is designed to strengthen the national economy and industrial productivity through the transfer and application of aerospace technology resulting from NASA's R&D programs. To accomplish this objective, NASA has established and operates a number of technology transfer mechanisms to provide timely access of useful technologies to the private and public sectors of the economy. Almost every part of U.S. industry is affected by the technology transfer process, especially in such areas as automation, electronics, materials, and productivity. In the public sector, medicine, rehabilitation, transportation and safety are areas in which aerospace technologies have been especially beneficial. The specific objectives of the program are:

- To accelerate and facilitate the application of new technology into the commercial sector, thus shortening the time between the generation of advanced aeronautics and space technologies and their effective use in the economy;

- To encourage multiple secondary uses of NASA technology in industry, education, and government, where a wide spectrum of technological problems and needs exist;

- To develop applications of NASA's aerospace technology, including its unique facilities, to address priority non-aerospace needs of the Nation.

OBJECTIVES AND STATUS

The Technology Transfer program promotes the transfer of technology developed in NASA's R&D programs to the public and private sectors of the U.S. economy. A network of Regional Technology Transfer Centers (RTTCs) and NASA installation Technology Transfer offices form the core of the Agency's technology transfer efforts. Technologies developed for the Nation's aerospace program are reused or re-engineered to provide new products and processes in the areas of transportation, energy, medicine, public safety, and consumer goods. The goal of the program is to broaden and accelerate the technology transfer process to realize additional dividends on the national investment in aerospace research. This will also help the United States to maintain its competitive position in the international marketplace.

Activities in FY 1993 include:

- Completing the state and local government linkages to round out the "grid" of the national technology transfer network.

- Maintaining the nationwide technology transfer network to support cooperative efforts with the Federal Laboratory Consortium, state-sponsored business and technical assistance center, and Small Business Development Centers. These linkages enable the Technology Transfer program to keep pace with growing industrial demand for information and technology transfer services.

- Improving the technology transfer capabilities of the Technology Transfer offices at the NASA Field Centers through more efficient and effective methods of documenting and archiving new technology developments; increasing their capabilities to "broker" cooperative agreements between their laboratories and commercial entities; and extending their outreach capabilities within their geographical environments to assist in their economic development efforts.

- Promoting awareness of NASA's Technology Transfer program and resources available to the public and private sector through a broad array of communications vehicles, such as: the Tech Briefs publication; Spinoff magazine; seminars and conferences (e.g. Technology 2002 which reached an audience of over 6,000 and featured 200 exhibits), etc.

- Continuing and completion of the development of the AdaNET repository and library, and implementing a pilot to test the applicability of reusable software components to NASA's software development needs.

- Continuing implementation of the National Technology Transfer Center (NTTC) at Wheeling Jesuit College.

- Strengthening and enhancing NASA's dual-use (NASA/commercial) research programs through the continuation of the Joint Sponsored Research program and the establishment of two small pilot NASA (field center based) Technology Commercialization Centers.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The title and structure of the Technology Transfer (previously Technology Utilization) program has been slightly modified from the FY 1993 Congressional submission. The adjustments were undertaken to modernize and clarify the display of the Technology Transfer budget. The primary change is the centralization of the programs for collection/evaluation/publication of technology information under the "Dissemination" element. The "Network" program is now more clearly defined as those activities which use and/or manage technology information (e.g. RTTCs), with the "Applications" program including only technology application engineering projects.

The overall Technology Transfer program was reduced by $2.7 million as a result of the reduced FY 1993 appropriation. The Civil Systems program, which includes the AdaNET and NTTC projects, remains unchanged. Funding for the Dissemination program is reduced due to the elimination of funding for further development of the Technology Utilization Network System (TUNS) and the elimination of funding for centralized technology evaluations. Funding for the Network activities, which primarily includes resources for the RTTCs remains unchanged. The Applications program is reduced due to the elimination of all planned new initiative technology applications project funding. These adjustments are offset by a $0.5 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Civil systems........................	13,000	6,500	6,500	3,400

The NTTC will continue to facilitate the transfer of federal technology to the private sector through operation of a national gateway/clearinghouse that links "technology inquirers" with federal laboratories. It will also fully establish a technology transfer training program for industry and government. The NTTC will actively foster teaming between federal laboratories and industry as well as state and local governments by acting as a broker in the establishment of cooperative technology transfer projects. The AdaNET software repository/library and a pilot study to test the applicability of reusable software components to meet software development needs will be complete in FY 1993. No AdaNET funding is included in the FY 1994 estimate, as the program is expected to be self-supporting.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Dissemination........................	5,800	5,900	4,695	5,600

Funding for the field center technology transfer offices will be enhanced to provide for increased outreach capability to conduct economic development activities in their geographical regions; increased capability to negotiate cooperative agreements with commercial firms; and increased ability to conduct "in-house" new technology evaluations. Preparation of NASA Tech Briefs magazine and related materials for publication will continue. Circulation of NASA Tech Briefs magazine is expected to reach well over 200,000 by FY 1994 (over 90 percent of whom are corporate managers, engineers or scientists). The Center for Aerospace Information (CASI) will also continue to provide support by responding to general and specific inquiries from public and private sources which request information concerning NASA technological developments and other technology transfer program products and services.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Network..............................	6,500	9,500	9,500	9,000

The RTTCs will continue to enhance and extend their state and local government linkages to insure the widest possible provision of technology transfer services to their geographical regions. Operation of both the Computer Software Management and Information Center (specializing in the transfer of NASA software on a cost-recovery basis) and the Technology Applications Center (assisting in the commercialization of space remote sensing technology and dissemination of NASA remote sensing data on a cost-recovery basis) will continue.

Applications..........................	7,200	9,800	8,800	8,900

The completion of many ongoing technology application projects is expected by the end of FY 1993. In FY 1994, funding will be available for several "new start" application projects. The review process for these projects will place increased emphasis on funding those projects in which a commercial partner has been identified, or for which a high probability for commercial success has been determined through market analysis.

The Joint Sponsored Research program begun in FY 1992 will also continue to accelerate the development of "dual-use" NASA mission technology that is also of value to the commercial sector.

The NASA field center based Technology Commercialization Centers begun in early FY 1993 will continue to assist commercial firms to develop NASA technology beyond the primary NASA mission use and into the commercial sector.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF ADVANCED CONCEPTS AND TECHNOLOGY

COMMERCIAL USE OF SPACE

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Commercial applications and enhancements	41,300	44,100	43,957	40,700
Commercial development support	3,300	5,300	5,063	4,100
Commercial transportation	59,100	76,900	74,207	91,100
Communications systems	11,400	13,600	11,652	9,200
Total	115,100	139,900	134,879	145,100
Distribution of Program Amount by Installation				
Johnson Space Center	40,000	53,150	51,819	69,160
Kennedy Space Center	800	1,550	650	1,840
Marshall Space Flight Center	1,100	1,850	1,140	920
Stennis Space Center	4,500	5,100	4,000	5,200
Goddard Space Flight Center	1,300	1,450	1,375	1,516
Ames Research Center	900	700	500	300
Langley Research Center	200	700	235	39
Lewis Research Center	4,500	6,390	3,466	2,512
Jet Propulsion Laboratory	1,500	1,741	991	1,116
Headquarters	60,300	67,269	70,703	62,497
Total	115,100	139,900	134,879	145,100

OBJECTIVES AND JUSTIFICATION

Objectives of the Commercial Use of Space (CUS) program are to develop opportunities for the expansion of U.S. private sector investment and involvement in civil space activities. The program is designed to:

- Foster close working relations with the private sector and academia that encourage investment in space technology and the use of the in situ attributes of space--vacuum, microgravity, temperature and radiation -- for commercial purposes.

- Facilitate private sector space activities through improved access to available NASA capabilities and the development of new high technology space markets.

- Encourage increased private sector investment in the commercial use of space independent of NASA funding.

- Implement and support commercial space policy NASA-wide.

The FY 1994 CUS program will be characterized by increased discipline and balance.

The CUS will use discipline and peer review to select projects and payloads. The CUS experiments program spans a range of promising commercial technologies. CUS expects to rely more heavily during FY 1994 on the scientific and technical expertise within the NASA community for project selection and oversight. Increased reliance on advisory groups will also contribute additional rigor to CUS programs.

The CUS experiment programs strike a balance between their pursuit of both short- and long-term commercial results. Guided by the need to select projects with strong commercial prospects, CUS programs support experiments likely to begin producing commercial results by the middle of the decade and well into the early years of the next century.

The CUS transportation programs have evolved in response to commercial customers' needs to access space in a systematic manner. The CUS investigators require more flight opportunities than are available through traditional NASA sources. The CUS initiated programs such as the Commercial Middeck Augmentation Module (CMAM) and the COMmercial Experiment Transporter (COMET) to respond to requirements for crew-assisted and/or long-duration flight.

To balance its transportation program and to optimize access to space, CUS relies on a series of test bed transportation systems, like KC-135 flights and sounding rockets. These systems provide additional short-duration microgravity flight opportunities. They provide low-cost opportunities for investigators to evaluate concepts and flight hardware. In addition, CUS expects to be a primary user of the Space Station, thereby providing commercial investigators a long-duration laboratory environment.

Both the CMAM and the COMET are proceeding successfully. Both systems are approaching their first flights in FY 1993. Follow-on flights for both systems are scheduled for FY 1994. The commercialization prospects for both systems are uncertain but each will provide economical flight alternatives for commercially-sponsored payloads.

NASA's goal of expanding opportunities for U.S. private sector investment and involvement in civil space and space-related activities is pursued through a variety of interrelated programs. Through cooperative agreements and partnerships via the Centers for the Commercial Development of Space (CCDS), CUS will increase the amount of space-related research conducted by the private sector, the number and type of NASA and private sector facilities available for space use, and the private sector awareness of opportunities to use NASA's terrestrial and space-based facilities for commercial research.

The CCDSs, a network of universities and private sector enterprises, are the primary mechanisms that CUS uses to achieve its space commercialization objectives. Seventeen CCDSs conduct applied research in fields with promising business prospects, including the fields of space propulsion, biotechnology, materials processing, space remote sensing, and communications. The CCDSs are:

1. Space Automation and Robotics Center, located at the Environmental Research Institute of Michigan, in Ann Arbor, MI. Focus: developing critical technology through demonstration flights for commercial space satellite servicing, retrieval and repair; developing robotics technology for automated laboratory activities in space and focused terrestrial applications of robotics technology.

2. Wisconsin Center for Space Automation and Robotics, located at the University of Wisconsin. Focus: to conceive, demonstrate and stimulate space and terrestrial commercialization of technology developed for space experiment automation, plant growth and life support systems, and the development of lunar fuel sources.

3. Center for Mapping, located at Ohio State University. Focus: to develop and integrate different capabilities into commercial opportunities for the suppliers of both space remote sensing systems and information systems.

4. Space Remote Sensing Center, a Division of the Institute for Technology Development, located at the John C. Stennis Space Center, MS. Focus: providing commercial technology applications development of satellite remote sensing, image processing, and geographic information systems.

5. BioServe Space Technologies, located at the University of Colorado at Boulder. Focus: developing technologies in the areas of biomedical isomorphisms, controlled ecological life support systems, bioprocessing and bioproduct research, and related hardware development task.

6. Center for Cell Research, located at Pennsylvania State University. Focus: physiological testing, bioseparations and bioprocessing, and equipment and environment design.

7. Center for Macromolecular Crystallography, located at the University of Alabama at Birmingham. Focus: space-grown crystals of biological materials, and developing technology and applications for the space-based material processing of biological crystals.

8. Advanced Materials Center, located at Battelle in Columbus, OH. Focus: multi-phase materials processing research in four technical areas: catalysts; metals and ceramics; polymers; and electronic and optical materials.

9. Center for Commercial Crystal Growth in Space, located at Clarkson University. Focus: developing commercial crystal growth in space and developing a broad spectrum of crystal growth techniques (melt, solution and vapor, theoretical modeling, complementary thermophysical property measurement, and structural and electronic characterization.)

10. Consortium for Materials Development in Space, located at the University of Alabama in Huntsville. Focus: developing commercial materials that benefit from unique attributes of space, and focus on commercial materials, commercial applications of physical chemistry and material transport, and prompt and frequent experiments and operations in orbit.

11. Space Vacuum Epitaxy Center, located at the University of Houston, TX. Focus: exploring R&D and commercial possibilities of thin film growth and materials purification in space.

12. Center for Space Power, located at the Texas A&M University. Focus: applied research relevant to space and related terrestrial power systems and developing industry partnerships to demonstrate technology associated with the commercial use of space.

13. Center for the Commercial Development of Space Power and Advanced Electronics, located at Auburn University, AL. Focus: to identify critical technological impediments to the economic deployment of power systems in space, promote and develop "dual use" technologies leading to new products that meet power generation, storage, conditioning, and distribution needs.

14. Center for Space Transportation and Applied Research, located at the Tennessee Space Institute in Tullahoma, TN. Focus: to develop industry partnerships that contribute to propulsion technologies that are considered prime in achieving basic space flight mission objectives.

15. Center for Materials for Space Structures located at Case Western Reserve University in Cleveland, OH. Focus: to develop and implement opportunities for U.S. industry to explore future materials for space structures that are suitable for being studied, used, or processed in space and that are capable of withstanding the harsh space environment. Promising research areas include polymeric composites, metallic composites, ceramic composites, organic coatings, and metallic coatings.

16. Center for Satellite and Hybrid Communication Networks located at the University of Maryland at College Park, MD. Focus: space-based communications, especially in the context of hybrid networks that integrate terrestrial and extra-terrestrial communications technologies.

17. Center for Space Communications Technology, located at Florida Atlantic University in Boca Raton, FL. Focus: to develop the commercial use of digital transmission techniques for transmitting video, audio and data to the Earth by satellite.

The CUS also manages a commercial remote sensing program through the Stennis Space Center. More than $5.0 million of FY 1994 resources will fund a remote sensing program at Stennis, providing a valuable complement to the experiments programs administered by the CCDSs. CUS expects to complete a targeted commercialization plan for the remote sensing program and to rely more heavily on a new advisory group. The result of the additional management and planning attention will be a better portfolio of projects with near-term commercial prospects. Included among the FY 1994 results will be commercial applications for agriculture, environmental monitoring, and natural resources management. One expected FY 1994 result, for example, will be the Airborne Terrestrial Applications Sensor (ATLAS) system. Attached to the Stennis learjet aircraft, the ATLAS system will begin data collection for environmental monitoring and mineral identification. CUS continues support of the Earth Observations Commercial Applications Program (EOCAP), also at the Stennis Space Center.

The CMAM contract, awarded to Spacehab, Inc., through open competition, involves flight accommodations and associated supporting services. This includes use of the commercially-developed CMAM flight modules and trainers, physical and analytical integration services, training of flight crews, and support to experiment

flight operations. The CMAM flight modules are pressurized, orbiter-based, mixed cargo carriers designed to augment the orbiter middeck by providing approximately 1100 cubic feet of additional volume for support of crew and payloads. Fifty middeck locker equivalents (MLEs) of payload space can be accommodated on each module. The CMAM is connected to the orbiter through a modified Spacelab tunnel adapter and draws resources from the orbiter cabin and cargo bay payload support provisions. Cooling, power, command/data and housekeeping systems (lighting, fire suppression, atmosphere control, status monitoring and crew emergency breathing) are provided. The CMAM is being procured under a lease-tenant arrangement. The first CMAM flight, scheduled for FY 1993, will accommodate payload experiments developed by seven different CCDSs.

The COMET is a fully integrated space transportation and recovery service to meet the needs of the commercial research and development community. This service, with three launches planned for the 1993-1995 time frame, will carry experiments to the microgravity of space and return those integrated into the COMET recovery vehicle. The COMET service module provides basic utilities such as electric power, controlled temperature, orientation, data management and communications while in orbit. The COMET provides flexible payload accommodations for a wide variety of materials and equipment. Each mission will launch a two-part (experiment facility) free flyer which will carry commercial microgravity, communications, and rendezvous and docking experiments into a nominal 300 nautical mile orbit. The recovery vehicle returns to land by parachute after 30 or more days in orbit. Access to the payloads in the recovery system is possible up to six hours before launch, enabling installation of degradable or limited-life materials. The COMET program was established and is being implemented by the Center for Space Transportation and Applied Research (CSTAR) located at the University of Tennessee Space Institute in Tullahoma, Tennessee. The first launch is scheduled for mid-1993.

In order to maintain momentum in Commercial Use of Space (CUS) activities and to encourage an increase in private sector investment in space, NASA will continue to develop methods to facilitate private sector agreements and commitments to pursue commercial opportunities in space. The development of agreements for the use of the Shuttle external tanks and private sector use of U.S. launch facilities reflect this effort.

The Advanced Communications Technology Satellite (ACTS) program will help the U.S. maintain its leadership in the communications satellite market by the development and flight verification of advanced technologies that will enhance the capability of communications satellites. The CUS program is responsible for the management of the ACTS user experiment program. The U.S. user community, consisting of private sector organizations and other government agencies, will develop and execute experiments that will test and evaluate the ACTS technologies under various applications scenarios. The key ACTS technologies include high effective isotropic radiated power; fast-hopping multiple beam antenna; on-board intermediate frequency and baseband switching; Ka-band components; and dynamic rain fade compensation techniques. The ACTS is planned for a Space Transportation System/Transfer Orbit Stage (STS/TOS) launch in 1993.

The Radio Science and Communications Satellite Commercialization program provides technical support for U.S. and NASA interests in international and domestic communications regulatory forums. For example, propagation in the measurements are performed in order to understand and account for the effects of signal propagation in the design and specification of space communications systems. Studies to enable new satellite applications are conducted.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The CUS program has been reduced by $6.3 million in response to Congressional appropriation action, but is preserving funding for its highest-priority transportation projects and the ACTS experiments program, consistent with Congressional direction, as well as the Wake Shield facility, currently being prepared for a 1994 flight.

The budget reductions in FY 1993 have been allocated among the remaining CUS programs. These include the cancellation of a sounding rocket flight that had been planned for FY 1993; reduction of support to sounding rocket and lower-priority payload development and associated payload integration; a reduction in program support contracts; and reduction of remote sensing projects at the NASA centers. CUS will also terminate a planned research announcement program for ACTS experimenters. These adjustments are offset by a $1.3 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Commercial applications and enhancements.......................	41,300	44,100	43,957	40,700

The CUS program will utilize FY 1994 resources to design, develop and prepare commercially-sponsored experiments for flight consistent with their current schedules. In collaboration with the CCDS network and with NASA's centers, CUS will continue to pursue an aggressive flight program supporting both near- and long-term commercialization activities. Resources will finance projects and activities across a number of technology areas, including materials processing, life sciences, remote sensing and space infrastructure.

CUS plans to conduct 50 payload tests in FY 1994. Most experiments will fly on the Space Shuttle (middeck or CMAM), and the COMET launch vehicle. Included in the FY 1994 program will be the first flight of the Wake Shield facility, scheduled to fly as an orbiter payload in November 1993. CUS will also use available

NASA aircraft to support remote sensing and other project activities. In addition, CUS will evaluate the potential benefits of future transportation systems and the program will continue the process of planning for Space Station utilization.

The CCDS network of universities will continue as the primary tool for conducting the program's commercial activities and, as in past years, the performance and workloads associated with the Commercial Applications and Enhancements program will directly involve other NASA offices, NASA Centers, other Federal agencies, and private industry. Management of the remote sensing element will continue to rely upon Landsat and the French SPOT, the two current sources of remotely-sensed data for commercial use, as sources for data imaging, analysis, transmission, and for value-added applications.

FY 1994 funding will also support analytical and physical integration required for Space Shuttle payloads flown by the CCDSs and under commercial cooperative agreements. Resources also support Space Shuttle optional services, for which reimbursement is deferred under some Space Systems Development Agreements (SSDAs). The CUS program's current SSDAs are with SPACEHAB, Inc., and Space Industries Partnership.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Commercial development support.........	3,300	5,300	5,063	4,100

The CUS will depend on its support program during FY 1994 to provide systems engineering studies, strategic analyses, and industry trend analyses that contribute to high-quality commercial project selection and management. Headquarters support contracts funded in this line for ADP, graphics, and related services will decline from previous years, consistent with the CUS desire to realign resources to direct program activities.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Commercial transportation.............	59,100	76,900	74,207	91,100
Commercial middeck augmentation module............................	39,000	51,400	51,407	66,500
Commercial experiment transporter	18,000	22,000	22,800	24,600
Sounding rocket	2,100	3,500	--	--

The CUS program's highest-priority transportation projects will be fully supported in FY 1994 -- the CMAM, supporting middeck-class experiments that require crew support, pressurization, late access and early retrieval, and ascent/descent power; and the COMET, an expendable launch vehicle system providing launch, low-Earth orbit operations, payload recovery, and long-duration microgravity. FY 1994 funding will enable the continuation of both these critical projects.

Although no funds are requested in FY 1994 for the Sounding Rocket program, the failure of an earlier JOUST rocket flight has resulted in a flight insurance reimbursement to the Consortium for Materials Development in Space CCDS. These funds will allow continuation of the program during FY 1994. Moreover, existing contractual arrangements with the service provider allow for the continuation of the Sounding Rocket program during FY 1995 and subsequent.

The CMAM request will support the second and third STS flights scheduled for November 1993 and June 1994, respectively. The FY 1994 COMET request will provide for the second flight, in September 1994, of three scheduled missions under the original procurement. Together, CMAM and COMET will support 29 payload tests during FY 1994.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Communications systems................	11,400	13,600	11,652	9,200

The CUS program will continue to respond to the emerging commercial research needs of the country's communications industry. A major contributor toward this objective includes the Advanced Communications Technology Satellite (ACTS) experiments program. Commercial interest in the ACTS program is accelerating as the satellite launch date approaches in mid-1993, and terminal development and acquisition will be emphasized in the FY 1994 program. By the start of FY 1994, CUS expects to have well over 50 experimenters working with the ACTS system with the list of experimenters expected to continue to grow.

As in other CUS program areas, a diversified ACTS experiments program is being pursued. CUS expects to complete the activation of eighteen T1-VSAT ground terminals and to conduct related experiments with the U.S. Army and with industry. CUS will complete activation of the Aero-Mobil terminal. It will initiate demonstrations and experiments for Land-Mobil and for Aero-Mobil. Following delivery of high data rate and ultra small aperture terminals, government and industry partners will activate them for an intensive series of experiments.

The ACTS experiments program will also benefit during FY 1994 from the results of a blue ribbon panel review of the ACTS experiments program which was completed during the first half of FY 1993. The blue ribbon review by a series of non-government experts was consistent with CUS's recent efforts to improve the quality and selection of its payloads and experiments. The intent of the panel review was to contribute to the selection of experiments with the most promising commercial prospects. One of the more promising commercial research areas, according to the panel, would be a series of experiments in support of the aeronautical and aviation industry. CUS intends to keep the ACTS experiments program focused on these and other high-potential areas.

In FY 1994, Communications Systems includes the NASA activities associated with the international Search and Rescue program, which has been previously budgeted and managed under Space Science and Applications. The budget estimate of $1.1 million will continue to support research and development leading to new or additional applications or capability improvements. Search and Rescue program operations remain the responsibility of the National Oceanic and Atmospheric Administration.

Advanced communications and propagation studies activities will be continued in FY 1994 at a reduced level and will support the development of the technical basis for standards development and for regulatory decisions at the national and international level. Propagation studies and measurements will also be sustained at a reduced level to fill voids needed to design new satellite applications for fixed communications, mobile communications, and sound broadcasting.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY FOR AERONAUTICS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Aeronautics research and technology....	788,192	890,200	865,587	1,020,700	RD 9-1
Transatmospheric research and technology..........................	4,136	80,000	--	80,000	RD 10-1
Total..........................	792,328	970,200	865,587	1,100,700	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS

AERONAUTICAL RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base	343,297	394,000	436,478	448,300	RD 9-5
Systems technology programs	212,122	253,000	280,284	428,900	RD 9-16
Research operations support	232,773	243,200	148,825	143,500	RD 9-39
Total	788,192	890,200	865,587	1,020,700	
Distribution of Program Amount By Installation					
Jet Propulsion Laboratory	2,400	2,500	2,990	3,600	
Goddard Space Flight Center	4,100	7,400	6,280	13,600	
Ames Research Center	259,000	299,200	286,317	320,000	
Langley Research Center	241,000	260,400	263,400	330,000	
Lewis Research Center	222,000	257,100	254,300	289,000	
Headquarters	59,692	63,600	52,300	64,500	
Total	788,192	890,200	865,587	1,020,700	

OFFICE OF AERONAUTICS — AERONAUTICAL RESEARCH AND TECHNOLOGY

OBJECTIVES AND JUSTIFICATION

The goal of the NASA program is to conduct aeronautical research and develop technology to strengthen U.S. leadership in civil and military aviation. The program is based on a strong commitment to develop a broad technology base in support of the aviation industry, enhance the safety and capacity of the national airspace system, and assure U.S. superiority for national security. The FY 1994 estimate reflects the need to address critical barriers and strengthen technology development in selected high payoff areas that are vital to our long-term leadership in aviation. NASA's aeronautics program is focused on six thrusts: (1) develop selected, high-leverage technologies and explore new means to ensure competitiveness of U.S. subsonic aircraft and to enhance the safety and productivity of the national aviation system; (2) resolve the critical environmental issues and establish the technology foundation for economical, high-speed air transportation; (3) ready technology options for revolutionary new capabilities in future high-performance fixed and rotary wing aircraft; (4) develop critical technologies and new methodologies for hypersonic-cruise and air-breathing space-launch vehicles; (5) pioneer the development of innovative concepts, and provide the physical understanding and the theoretical, experimental, and computational tools required for the efficient design and operation of advanced aerospace systems; and (6) develop, maintain and operate critical national facilities for aeronautical research and for support of industry, Department of Defense (DOD) and other NASA programs. In accomplishing these thrusts, the program will maintain NASA laboratory strength, including enhanced experimental and computational capabilities and staff excellence; ensure timely domestic technology transfer; ensure strong university involvement; and ensure strong support for and cooperation with the DOD, Federal Aviation Administration, and industry partners.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The aeronautics research and technology program reflects an overall decrease of $24.6 million. The research and technology base has been increased by a net of $42.5 million. A new discipline research program for hypersonic research has been established within the aeronautics research and technology base to consolidate total funding for these activities and give visibility to this program. The space research and technology portion of hypersonic funding ($5.1 million) has been reallocated to the aeronautics research and technology base to complete this consolidation. This increase to the research and technology base was offset by a reallocation of $2.1 million to Research Operations Support (ROS) for financial management system upgrades. An additional $39.5 million has been reallocated to the research and technology base as a result of the redistribution of ROS funding.

During FY 1993, a detailed Agencywide examination of activities supported by ROS funding was conducted to identify activities directly related to programmatic activities. Funding for activities dedicated to individual programs has been transferred to the benefiting programs. In total, the portion of ROS allocated to in the aeronautics program has been reduced by $94.4 million. This reflects the transfer of $82.3 million consistent with the restructuring activity and a reduction of $14.3 million consistent with Congressional direction. These reductions were offset by the reallocation of $2.2 million for financial management system upgrades at the Ames, Langley and Lewis Research Centers.

In the systems technology area, high-performance computing was reduced by $5.0 million consistent with Congressional direction. Some planned activities have been descoped or delayed to accommodate this decrease. Proposed FY 1993 supplemental legislation would provide an additional $4.7 million for this program. As directed by Congress, the rotorcraft systems technology program has been increased by $1.3 million, which will be used to fund detailed multidisciplinary analysis of a low noise rotor. As a result of Congressional action on the FY 1993 budget request, the high-speed research program been increased by $25.0 million, which will be used to augment NASA's ongoing program to initiate the highest priority areas in propulsion and airframe technology necessary for timely high-speed civil transport technology development. Also, a total of $6.0 million has been allocated to the systems technology programs as a result of the redistribution of ROS funding.

BASIS OF FY 1994 ESTIMATE

The FY 1994 research and technology program is committed to providing a broad foundation of advanced technology to strengthen the United States' leadership in aviation, an industry which plays a vital role in the economic strength, transportation infrastructure, and national defense of the United States. Today, we as a nation are being challenged by foreign competition, by an increasingly strained national airspace system, and by uncertainties about the future of the defense sector of the industry. Because of the importance of aeronautics to the country at this time, and the many ways in which NASA's unique research capabilities contribute to strengthening American aviation, the aeronautics program is being augmented as part of the NASA new technology investments in FY 1994 to pursue the high-leverage technologies required to support both the subsonic and high-speed civil transport economic viability. These augmentations are essential to the technology to ensure U.S. leadership for future competition of a high-speed civil transport and to address the important competitiveness and capacity issues associated with future subsonic transport aircraft. The demands for NASA's unique wind tunnels and other aeronautical facilities continues to increase with the growth of technology involved with civil and military aircraft development and modification programs. In order to support wind tunnel availability to meet these demands, continued emphasis will be placed on maintenance, instrumentation and revitalization of these unique national facilities. In FY 1994, the R&D augmentation for national facilities upgrade will be used for the development of design approaches and enabling technology for the highest priority needs for advanced facility capabilities.

In FY 1994, a number of programs are being realigned from systems technology into the research and technology base to consolidate activities of a similar nature. These include rotorcraft technology, advanced high-temperature engine materials technology, high-performance flight research, and general aviation/commuter core engine technology. Within systems technology, the ongoing noise reduction work which has been done under advanced propulsion systems technology is being realigned to the advanced subsonic technology program which it supports.

C-3

BASIS OF FY 1994 FUNDING REQUIREMENTS

RESEARCH AND TECHNOLOGY BASE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aerodynamics research and technology...	127,371	140,100	154,800	154,500
Propulsion and power research and technology..........................	78,896	83,900	87,100	90,400
Materials and structures research and technology..........................	38,068	40,600	35,100	48,500
Controls, guidance and human factors research and technology............	49,329	73,500	66,400	59,400
Flight systems research and technology.	41,091	45,500	48,800	56,300
Systems analysis......................	8,542	10,400	11,650	10,200
Hypersonic research and technology.....	--	(25,600)	32,628	29,000
Total...........................	343,297	394,000	436,478	448,300

OBJECTIVES AND STATUS

The overall objective of the research and technology base program is to provide a strong fundamental foundation for future aviation advances. Major emphasis is on fundamental understanding of a broad range of physical phenomena, development of computational methods to analyze and predict the physical phenomena, and appropriate experimental validation. These efforts ultimately lead to design and analysis tools with application to each of the six aeronautical strategic thrusts.

Aerodynamics research and technology addresses a broad spectrum of fluid flow problems from fundamental fluid physics to applied aerodynamics. These investigations include analytical and experimental efforts across the speed range for application to all classes of civil and military aircraft. The advanced computational methods developed by this research are used for more accurate and efficient prediction of aircraft aerodynamic performance, as well as for exploration of fluid physics phenomena. These fluid mechanics research efforts in FY 1993 are producing an improved understanding of flow transition mechanisms and turbulence dynamics, increased simulation and modeling capability, and provide the basis for new flow control concepts. Computational methods research also emphasizes the development and validation of advanced

analytical tools, including improved methods for configuration surface modeling and grid generation. Research in experimental techniques includes advanced sensor development for wind tunnel and flight testing. Nonintrusive global measurements were examined to reduce the time required to obtain surveys for data analysis and validation of computational methods. Luminescent paint for wind tunnel models is a revolutionary technique developed to provide real-time sensing of pressures over entire model surfaces. In the subsonic regime, flight and wind tunnel testing, as well as computational studies, were performed to improve aerodynamic efficiency and reduce noise. In FY 1993, the analysis of flight test results was continued on hybrid laminar flow control applied to a Boeing 757 aircraft to reduce drag. High-lift flap technology was advanced with analysis of flight data taken on the transportation systems research vehicle (TSRV). Vortical flow analyses and flight control methods were developed to provide improved handling qualities of high-performance aircraft at high angles-of-attack. Rotor research activities included initial flight airloads testing for acoustics and loads prediction. Advanced rotor and low noise airfoils were tested in the 40x80-foot wind tunnel.

The objective of the propulsion and power research and technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components. The propulsion research and technology program has been devoted to increasing engine efficiency of next-generation large turbofans resulting in up to 30-percent reduction in fuel consumption. Preliminary studies indicate that these advanced turbofans will require very high operating pressure ratios (60:1 or greater), and temperatures (about 3000 degrees Fahrenheit) to achieve significant fuel reduction. Control of engine emissions at higher temperatures and pressures will be a key element of the propulsion technology development effort to reduce the adverse impact of subsonic aircraft engine emissions on the environment. In FY 1993, in-depth studies are being conducted in conjunction with industry to define critical propulsion technologies and engine configurations for the next-generation subsonic aircraft. The propulsion program will have addressed the selection of high-efficiency engine concepts using parametric analysis of various propulsion systems with varying bypass ratios and pressure ratios. The selection of the optimum configuration includes consideration of low-noise concepts, reduced emissions and the impact of engine airframe integration, while achieving high levels of engine performance. Disciplinary research in instrumentation, controls and internal fluid mechanics will be focused on propulsion technology areas including inlets for supermaneuvering vehicles, combustors and turbomachinery.

The materials and structures research and technology program is developing advanced materials, analysis methods, test methods and structural concepts to enable the design of safe, lightweight airframes and lightweight, durable, fuel-efficient engines. Materials and structures research is focused on understanding fundamental behavior, developing life prediction methodologies, and advancing fabrication technology for light metals, composites and high-temperature materials.

Computational structures technology is concerned with advanced analytical methods, from the micromechanics level through global response of full-scale aircraft, aeroelastic response and control, and multidisciplinary design and optimization. Under airframe materials research, work on processability and optimization of high-temperature resin RP46 is in progress. This material is a replacement for PMR-15 as a candidate material to be used in primary airframe structures. Laboratory research on high-temperature composites IM7/5260, IM7/8320, and IM7/K3-B is in progress to establish the relationship between physical aging and long-term creep and stress relaxation behavior. Optimized preparation of high-temperature polymer/graphite towpreg to be woven into fabric and evaluation of the composite properties are scheduled for FY 1993 completion. Fundamental mechanisms involved in oxidative degradation were experimentally investigated and efforts were initiated to develop analytical predictive models. Advances were made in chemical vapor deposition (CVD) methodology and predictive methods under the advanced fibers and fiber coating development effort. A computer code incorporating life prediction methodologies for high-temperature ceramics was completed. A benchmark test facility for biaxial high-temperature testing of generic engine components was designed and equipment is on order. Research efforts in aeroelasticity included benchmark models to measure unsteady aerodynamic pressures which were then used to validate aeroelastic computer codes. Computational structures technology (CST) continues to advance with demonstrated use of massively parallel computers in airframe and engine applications. More efficient ways of analyzing structures with defects, cutouts, etc. using the global/local approach were demonstrated.

The controls, guidance and human factors research and technology program supports applied research in the areas of flight crucial systems, airborne windshear detection, controls for highly agile aircraft, advanced cockpit and air traffic control integration with flight management systems, automated guidance and control for nap-of-the-Earth rotorcraft flight, and analysis of human performance in interaction with system automation. The program provides a technology base supporting future aircraft designs for safer and more efficient operations and greatly expanded flight envelopes and increasing National Airspace System capacity. A number of technology products will reach the state of maturity in which they are being validated in flight and in operational field tests in FY 1993. Operational tests of air traffic controller automation aids leading to increased system capacity were successfully undertaken in cooperation with the Federal Aviation Administration. Automated nap-of-the-Earth rotorcraft guidance concepts underwent flight evaluation in a cooperative effort with the Army. Flight crucial systems research on fly-by-light/power-by-wire applications will develop and test analytical and experimental methods for assessing electromagnetic effects on candidate system designs. The airborne windshear sensor program conducted flight evaluations of lidar (laser radar), infrared and Doppler microwave radar sensors to characterize performance in the presence of ground clutter and rain backscatter effects. Human factors research continued to focus on flight management, human engineering methods and cockpit automation aids. Flight evaluation of data link information transfer and in-flight planning/replanning aids was conducted using the TSRV. Full mission

simulation and empirical evaluation of electronic checklist designs, taxi way displays for low-visibility operations, and three-dimensional auditory cockpit displays for localization of traffic were completed. A design philosophy and guidelines for "human-centered" automation were developed and published.

Flight systems research and technology addresses a broad range of needs supporting aviation safety, flight test instrumentation and test techniques, and flight research for advanced technology demonstration/validation. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel testing and flight research. Flight research is conducted using military high-performance aircraft to take advantage of their robust flight envelope, availability of production and experimental aircraft, and the available operational support. In aviation safety, a research program is being conducted to improve the fundamental understanding of aircraft operation during icing conditions. NASA's ice accretion prediction methodology, currently in wide use in the aviation industry, is being extended to the special problem of predicting glaze ice buildup. In short take-off and vertical landing (STOVL) technology, a small-scale hot gas ingestion vertical/short takeoff and landing (V/STOL) model has been constructed and is scheduled for test in the Lewis 9x15-foot low-speed wind tunnel. The high angle-of-attack research program is obtaining a flight-validated data base for design of highly agile aircraft. The high angle-of-attack research program continues to explore maneuverability and agility technology. Wind tunnel and flight-validated prediction methods are enabling aircraft designers to develop advanced concepts with high maneuverability and to design modifications for existing aircraft to enhance performance. Advanced computational fluid dynamics methods have been used to calculate the flowfield around the full F-18 high angle-of-attack research vehicle (HARV) configuration and within the inlet duct. Excellent correlation to data obtained from the F-18 HARV flights has been achieved for the external flow field. An inlet rake has been designed, fabricated and installed in the F-18 HARV for acquisition of data to validate the internal flow CFD code. The final design and fabrication for the F-18 HARV mechanical forebody vortex control device has been completed. Envelope expansion into the high angle-of-attack regime is continuing on the X-31 enhanced fighter maneuverability (EFM) aircraft in support of the Department of Defense. This vehicle is exploring post-stall maneuverability in the combat environment using lightweight external thrust vectoring vanes and an advanced multivariable flight control system. Initial SR-71 flight operations have been completed, providing an evaluation of operational costs and supportability in a flight research environment. An assessment of national requirements indicates the SR-71 will be useful in supporting high-speed and science research.

The aeronautics systems analysis program conducts long-term technology assessments, identifies technology applications, and performs sensitivity analyses and tradeoff studies from which effective research and technology programs can be developed to meet future civil and military aircraft requirements. Studies conducted under the systems analysis program focus on defining high-leverage, long-range research and technology needs for specific vehicle classes. In addition, the element includes work to develop advanced analytical techniques, and design and integration capabilities. Current efforts include conceptual design studies and environmental impact analyses for supersonic transport aircraft and propulsion systems. These

studies have shown that noise-reduction requirements will be a major consideration in airframe/engine integration for this class of aircraft. Also, supersonic laminar flow has shown the potential for greatly improved wing efficiency. Other studies are investigating technology tradeoffs for large subsonic transports, advanced rotorcraft, and high-performance aircraft to enable the most effective use of research resources. Methods development work in FY 1993 includes enhancing multidisciplinary analysis with advanced geometry and data management methods, and linking it to an optimization module.

The hypersonic research and technology program utilizes NASA expertise and facilities in conjunction with university and industrial research to develop advanced, next-generation, high-risk/high-payoff, hypersonic technologies providing major innovative ''leaps'' in hypersonic vehicle performance which will ensure continued U.S. leadership in aeronautics. The program focuses fundamental research and technology development within the disciplines of ram/scramjet propulsion, aero/aerothermodynamics, materials, structures, guidance and control, technology integration, and the improvement of test techniques which will provide major advancements in future airbreathing, hypersonic launch vehicles, including single and two stage-to-orbit concepts. The program is currently conducting computer simulations to ascertain surface roughness effects on hypersonic laminar flow stability and will be completing development of a three-dimensional Navier-Stokes reacting flow code using multigrid, multiblock solvers. Advanced fuel injection and mixing concepts to increase scramjet supersonic combustion efficiencies are being studied. Room temperature testing of an advanced carbon-carbon control surface for a hypersonic vehicle is being completed. The program is evaluating the propulsion system sensitivity to aeroelastic deflections of slender, hypersonic vehicles. Rayleigh and laser-induced fluorescence techniques are obtaining planar ''snapshots'' of turbulent phenomena in high-speed mixing and combustion flows. Through joint efforts with industry, integrated multidisciplinary modeling and analysis tools are to be extended to include full computational fluid dynamics (CFD) implementation of multicycle combustion systems for complete vehicles. The program is broadening the effort in the development of university centers for training students and conducting research in hypersonic aeronautics with the intent of providing future experts in multiple hypersonic disciplines for U.S. industry, universities and the government. The current program has already produced 72 Masters and 57 Doctorate graduates in the fields of aerodynamics and aerothermodynamics.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The aeronautics research and technology base reflects a net increase of $42.5 million. A new discipline has been established within the aeronautics research and technology base for hypersonic research to consolidate total funding for these activities and give visibility to this program. The space research and technology portion of hypersonic funding ($5.1 million) has been reallocated to the aeronautics research and technology base to complete this consolidation. A total of $2.1 million has been reallocated from the aeronautics research and technology base to Research Operations Support (ROS) for financial management system upgrades, and $39.5 million has been reallocated to the research and technology base as a result of the redistribution of ROS funds.

The changes by the discipline program are as follows:

The aerodynamics research and technology program has been increased by $14.7 million. A total of $5.8 million of hypersonic funding has been reallocated to the newly established hypersonic discipline, $0.4 million was transferred to ROS for financial management system upgrades, and $0.9 million has been realigned from the high performance area to support other high priority requirements.

Increases within this program include fundamental technology efforts applicable to subsonic technology ($2.0 million), high-speed technology ($1.3 million), computational aeroacoustics ($0.6 million), and wind tunnels and technical facilities ($3.7 million). In addition, $14.1 million has been allocated to this program as a result of the redistribution of ROS funds.

Propulsion and power research and technology was increased by $3.2 million. This includes the allocation of $11.4 million to the hypersonic discipline, $0.3 million transferred to ROS for financial management system upgrades, and a $1.3 million reduction in high-performance efforts. These reductions have been offset by increases of $2.0 million for rotary engine research, $1.7 million for high-pressure/temperature simulation, $1.0 million for supersonic cruise efforts, $0.9 million for wind tunnels and technical facilities, $0.2 million for computational aeroacoustics, and $10.4 million as a result of the redistribution of ROS funds.

The materials and structures research and technology program reflects a reduction of $5.5 million. This includes an allocation of $4.7 million to the hypersonic discipline and a realignment of $3.6 million to all speed regimes to support high priority subsonic activities in other research and technology base programs, which has been offset by the reallocation of $2.8 million from ROS.

The controls, guidance and human factors research and technology program has been decreased by $7.1 million. This is the net effect of a number of actions, including allocation of $1.7 million to the hypersonic discipline, a realignment of $1.4 million to ROS for financial management system upgrades at the research centers, and a general reduction of $6.5 million across all elements of the program to support other high priority research and technology base activities. Within this program, funding has been redirected to support transport system research vehicle upgrades ($2.0 million) and flight management efforts ($0.5 million). In addition, $2.5 million has been allocated to this program as a result of the redistribution of ROS funds.

Flight systems research and technology has been increased by $3.3 million. This includes a reduction of $3.1 million in the supersonic research to support other high priority research and technology base activities which has been offset by the transfer of $6.4 million from ROS. Within this program, $1.1 million has been realigned from the high-performance effort to support flight research activities and the optical air data system. The systems analysis program has been increased by $1.3 million as a result of the redistribution of ROS funds. In addition, $2.0 million was allocated to the hypersonic discipline, and this has been offset by an increase of $2.0 million to support subsonic systems analysis studies.

Hypersonic research and technology ($32.6 million) has been established as a separate discipline within the research and technology base to give visibility to these activities. This represents a consolidation of hypersonic funding previously in other aeronautics research and technology base disciplines ($25.6 million), the hypersonic funding previously funded in the space research and technology base ($5.1 million), and a transfer of $1.9 million resulting from the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

Aerodynamics research and technology will continue to address a broad spectrum of fluid flow problems from fundamental fluid physics to applied aerodynamics in FY 1994. Computational methods will be applied on computers with advanced architectures and include improved methods for representing the surface of aerodynamic configurations being modeled, improved techniques for rendering the locations being considered, as well as advanced modeling of the algorithms used to solve the fluid flow equations. In addition, a multidisciplined approach will be undertaken to expand the scope of computational fluid dynamics to properly account for propulsion, chemical processes, structural effects and flight control laws. Experimental research will be expanded to include techniques such as the use of heavy gas in wind tunnels to provide Reynolds numbers higher than available from air, but closer to aircraft flight Reynolds numbers. A closer association between computational fluid dynamics and advanced techniques will result in nonintrusive global measurement techniques to reduce the time required for accurate flow field surveys and computational methods validation. In 1994, a joint NASA and industry program will be initiated to resolve discrepancies that were encountered in the laminar flow flight testing of the Boeing 757 aircraft. A wind tunnel model will be designed and fabricated for joint testing in a NASA or Boeing facility in 1995. The results from current wind tunnel and flight tests on the TSRV aircraft will be used to validate two-dimensional computational programs on high-lift devices. Rotorcraft aeroacoustics and high-speed rotorcraft were moved from systems technology to the aerodynamics research and technology base program. Two major activities from that area will be completed under the rotorcraft base program in the FY 1994 time frame. First, a major inspection, and subsequent rehabilitation of the XV-15 tiltrotor aircraft will be complete prior to undertaking an acoustic and terminal area flight investigation in FY 1995. To support that activity, tests will be undertaken on the vertical flight simulator in order to define the test matrix for the flight tests that are scheduled for FY 1995. In FY 1994, the national facility augmentation will be used to develop design approaches and enabling technology for the highest priority advanced facility needs.

In FY 1994, propulsion and power research and technology will focus on high-pressure ratio compressors, high-temperature and low-emission combustors and high-temperature turbines. The propulsion technology will continue to define the details of subscale component technologies for both the cold and hot end sections of the propulsion system with an emphasis in the high-pressure turbine, and low-emission combustor components. The program effort will be focused on development of the technologies for the specific engine concepts and configurations that are consistent with the industry's vision of the next-generation high-bypass-ratio turbofans.

The general aviation/commuter engine technology effort which has been realigned from systems technology will continue to demonstrate component improvements through the practical application of validated analysis codes that will enable high-performance small engine systems. Experimental data acquired from combustor ceramic liner tests and using three-dimensional Navier-Stokes two-phase reacting flow code will provide the required design input for demonstration of an advanced combustor with a very aggressive pattern factor of 0.1 at a combustor exit temperature of 2800 degrees Fahrenheit. Novel fuel injection concepts will be developed for small combustors. A combination of these new concepts and high-temperature combustors for high-pressure ratio, small core engines will lead to reduced fuel consumption. For turbomachinery, axial flow compressor experimental data will be used for validation of multistage average passage code to design and predict axial compressor performance.

The <u>materials and structures research and technology</u> efforts will continue to focus on developing advanced materials and innovative structural concepts which can reduce aircraft weight and cost, enhance performance and durability, and improve aircraft safety. Improved understanding of the impact of material processing parameters on material performance under complex loading conditions will be used to tailor overall material development activities including intelligent processing. Materials research activities will include development of high-temperature organic composites for use up to 800 degrees Fahrenheit, and high-temperature aluminum alloys for design applications up to 450 degrees Fahrenheit. Processing scale-up of the high-temperature resin RP46 will be completed and this material will be made available for commercial use. Research in advanced materials will include micro- and macromechanical modeling of high-temperature, time-dependent behavior such as creep and fatigue. Creep and toughness properties and failure mechanisms of General Electric's nickel aluminide alloys for turbine blades will be examined to guide General Electric's development effort. Failure modes/mechanisms from long-term aging of graphite/PMR-15 composites will be identified and engine component specific analytical models to predict service life at temperatures from 400 degrees Fahrenheit to 650 degrees Fahrenheit will be developed. During FY 1994, structures research will include a focus on developing improved coupled thermal/aerodynamic/structural analysis and accelerated test methods for aircraft structures and propulsion systems. Unsteady aerodynamics research will be directed toward expanding aeroelastic and flutter analysis capability for complete airframe structures, using advanced three-dimensional analytical methods with improved accuracy and lower cost, and benchmark wind tunnel tests to verify analytical predictions. Also planned is the development of multidisciplinary coupled finite element and computational fluid dynamics capability for transonic aeroelasticity. These areas will be supported by real-time flight aeroelastic data analysis capability. Research in structural mechanics will include evaluation of the effects of tailored stiffness and thickness distributions on the behavior of composite plates and shells. Efforts in the propulsion structures area will provide computational simulation of a complete engine accounting for coupled aerodynamic and structural effects. A working version of the engine structures computational simulator (ESCS computer code) will be delivered.

The advanced high-temperature engine materials program (HITEMP), which has been realigned from systems technology, will continue to focus on development of lightweight, high-temperature polymer matrix composites (PMC's) for fan and compressor applications up to 800 degrees Fahrenheit: intermetallic matrix composites

and metal matrix composites (IMC's and MMC's) for compressor and turbine applications up to 2300 degrees Fahrenheit; and ceramic matrix composites (CMC's) for turbine applications up to 2500 degrees Fahrenheit. A new fiber sizing for 700- to 800-degrees-Fahrenheit use and polymer coatings which are resistant to oxidation up to 800 degrees Fahrenheit will be developed. A fiber/matrix interface model designed to help overcome the incompatibilities between current ceramic fibers and intermetallic matrix materials will be verified and a new, more compatible ceramic fiber will be demonstrated. IMC efforts will also emphasize development of oxidation-resistant coatings, thermal barrier coatings and joining techniques. Oxidation-resistant fiber coatings for CMC's will be demonstrated, and processing methods will be optimized and transferred to industry. The performance, economic and environmental benefits of PMC's, IMC's and CMC's will continue to be verified in core and engine tests through ongoing cooperative efforts with the major U.S. gas turbine manufacturers.

In the <u>controls, guidance and human factors research and technology</u> program, the area of flight crucial systems will continue to place emphasis on the development and validation of design and assessment tools which support cost-effective certification of highly reliable electro-optical flight systems and on methods for automated development of reliable software. Emphasis will be placed on the application of analytical and experimental tools developed for assessing electromagnetic effects on electro-optical flight systems. The successful completion of windshear sensor and integration tests in FY 1993 leads to application of windshear alerting technologies for other aviation hazards, and insertion of those technologies in flight deck and National Airspace System integration efforts in FY 1994. Evaluations of automated aids for air traffic controllers were undertaken in the Denver terminal area. In FY 1994, the final approach spacing tool will be installed at Dallas-Fort Worth for evaluation. Simulation and flight evaluation of cockpit automation aids will be conducted, and increased emphasis will be placed on investigating the integration of aircraft equipped with advanced technologies, such as synthetic vision, data link and global positioning system (GPS), into the National Airspace System. In the area of enhanced agility for highly maneuverable aircraft, new control laws for mechanical control of vortices are being flight-tested in the HARV. Evaluation of helmet-mounted display for highly maneuverable aircraft will be undertaken in ground-based simulation in FY 1994 preparatory to 1995 flight tests. Flight evaluation of vision-based passive ranging algorithms, required for rotorcraft nap-of-the-Earth flight guidance, will be completed in FY 1993. Installation of a precision GPS-based navigation system, helmet-mounted display system, and a guidance computer in the UH-60 RASCAL helicopter will be completed in FY 1994. Generic research in controls is aimed at developing error-tolerant flight system technology through advanced active control theory, integrated engine airframe controls and artificial intelligence-based controls. Fundamental research in human factors will continue to develop scientific principles and ''human-centered'' technologies to improve design efficiency and operational safety of advanced flight systems by providing methods to reduce the operational impact of human errors. Efforts in FY 1994 will focus on integrated ''human-centered'' advanced subsonic aircraft cockpit development and test, and on identification of human capabilities and limitations in the flight deck and National Airspace System integration for increased terminal area productivity. Research and field evaluations of fatigue countermeasures for air crews, such as evaluation of in-flight bunk-sleep facilities, will continue. The current technology glass cockpit simulator is being installed in FY 1993 and ready for research in FY 1994.

In flight systems research and technology, experiments will be conducted to validate the ability of prediction methodologies to accurately describe the shape of the three-dimensional ice build-up on airplane wing and tail surfaces. A joint NASA/Sikorsky test of a subscale helicopter rotor model to acquire further data on rotor blade performance in icing conditions will be completed in NASA's Icing Research Tunnel. The portion of the high angle-of-attack research program element in the high-performance aircraft systems technology program has been consolidated herein and the program will concentrate on technology validation experiments. These experiments are focused on flight validation of the most promising new technologies, including advanced controls for thrust vectoring, mechanical forebody vortex controls, and wide-angle helmet-mounted displays. Advanced thrust vectoring control laws designed for agility will continue to be flight tested during FY 1994. Installation and checkout of the mechanical forebody vortex controls will occur and flight research will begin. Military utility evaluation of the X-31 will be completed. The Defense Advanced Research Projects Agency (DARPA) has initiated the STOVL strike fighter technology demonstrator program; consequently, the objectives of NASA's STOVL research and technology have been reassessed. The STOVL program now aims to support DARPA with NASA's unique technology expertise and facilities to ensure success of the DARPA STOVL strike fighter program. Integration of the integrated flight/propulsion control software and servos on the V/STOL research aircraft, YAV-8B Harrier, will be completed and the initial flight experiments begun (transferred from systems technology). These experiments investigate guidance/display schemes and integrated flight and propulsion concepts for the hover and transition flight regimes. Continued support for the design, fabrication, installation, definition and conduct of experiments benefiting a high-speed civil transport (HSCT) provide the major focus for the SR-71 flight research testbed for FY 1994. The advanced propulsion/flight controls integration research is being transferred from systems technology. This activity will use the F-15 STOL and maneuver technology demonstrator and will incorporate axisymmetric vectoring engine nozzles. The aircraft engines will be fitted with the new nozzles, and flight research will be initiated to improve aircraft performance and safety.

In FY 1994, the aeronautics systems analysis program will continue the development of analytical and multidisciplinary design methods. Conceptual design methodology will be expanded to include cost as a primary optimization function and incorporate analytical models for weight and cost on a component basis. The resulting methodology will be implemented on a parallel computing system in order to provide adequate computing power for the increased complexity and detail currently envisioned. Supersonic transport studies will continue with an investigation of propulsion/airframe integration concepts. A detailed evaluation of the supersonic throughflow fan propulsion system will be completed. Alternative concepts for an HSCT, emphasizing configurations that are optimized for supersonic laminar flow, will be explored. The preliminary design of an efficient propulsion system with low noise and emissions for an advanced subsonic transport will be completed. High-performance aircraft studies will analyze the benefits and technological costs of increasing agility according to refined agility metrics.

Hypersonic research and technology will continue to concentrate on the development of innovative, high-risk/high-payoff technologies which will provide the foundation for future competitive aeronautical systems. Hypersonic aerodynamics researchers will investigate fundamental hypersonic flow mechanisms with emphasis on predicting transition location and turbulence development, methods for effective airframe/propulsion integration on advanced hypersonic vehicles, and gas aerothermodynamics phenomena. Hypersonic propulsion activities will be focused on the completion of semidirect connect tests of an advanced ramjet/scramjet engine design for verification of thermal choking and stable ramjet-to-scramjet transition (Mach 3.5 to 5) using nonintrusive laser diagnostics. Continued investigation of lightweight, high-temperature structural materials with applicability to hypersonic vehicles, other aeronautical systems and other industries will include increased emphasis on carbon-carbon materials and structures technology for both airfoil leading edges and scramjet engine panels, development of novel methods for processing graphite/copper metal matrix composites, and advancement of fundamental understanding of hydrogen degradation mechanisms in a variety of promising lightweight, high-temperature alloys. Analyses of the aeroelastic deflections of slender vehicle forebodies and the resulting propulsion transients will be continued to resolve the controllability issues associated with hypersonic flight dynamics. Through joint efforts with industry, integrated multidisciplinary modeling and analysis tools will be advanced by coupling massively parallel processing techniques with multiparameter optimization methods, which will then be applied to real airplane data. The development of advanced sensors and measurement systems for operation in the severe hypersonic environment will continue with further development of high-temperature sapphire fibers and optical test techniques to 2500 degrees Fahrenheit. The impact of boundary-layer crossflow transition on the performance of airbreathing hypersonic vehicles will be obtained in flight using a specially designed glove on the PEGASUS space launch booster wing. This "piggy-back" flight experiment on a scheduled PEGASUS satellite provides the opportunity to obtain real flight data at a minimum cost. In addition, three universities will be in their second year of participation in the continuing hypersonic training and research program.

BASIS OF FY 1994 FUNDING REQUIREMENTS

SYSTEMS TECHNOLOGY PROGRAMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
High-performance computing.............	16,980	35,000	30,359	65,600
Materials and structures systems technology.........................	37,562	35,500	36,628	*25,700
Rotorcraft systems technology..........	4,900	5,400	6,977	*
High-performance aircraft systems technology.........................	10,700	11,900	12,070	*
Advanced propulsion systems technology.	15,180	16,000	16,900	*
Numerical aerodynamic simulation.......	45,400	47,000	47,930	49,100
High-speed research....................	76,400	89,900	116,995	187,200
Advanced subsonic technology...........	5,000	12,300	12,425	*101,300
Total..........................	212,122	253,000	280,284	428,900

* Materials and structures systems technology: Advanced high-temperature engine materials ($10.523) transferred into the materials and structures portion of the research and technology base.

* Rotorcraft systems technology: Advanced rotorcraft ($5.280) transferred into aerodynamics portion of the research and technology base.

* High-performance aircraft systems technology: High-performance flight research ($9.570) transferred into the flight systems portion of the research and technology base.

* Advanced propulsion systems technology: General aviation/commuter engine technology ($3.085) transferred into the materials and structures portion of the research and technology base and advanced turboprop systems ($15.246) transferred into advanced subsonic technology.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
High-performance computing.............	16,980	35,000	30,359	65,600

OBJECTIVES AND STATUS

The High-Performance Computing and Communications (HPCC) program is a multi-agency endeavor which involves NASA, the Department of Energy, the National Science Foundation, the Department of Defense (DOD), the Department of Commerce, the National Institutes of Health, and the Environmental Protection Agency.

The goal of NASA's portion of the HPCC program is to accelerate the development and application of high-performance computing technologies to solve the Agency's Grand Challenge research problems. Grand Challenges are fundamental problems whose solutions require significant increases in computational power and are critical to meeting national needs. The NASA HPCC program is focused to enable broad advances in aerospace vehicle design and Earth and space systems science research.

NASA's primary role in the federal program is leading the development of applications software and algorithms suitable for massively parallel computing systems which will increase system performance to the sustained teraFLOPS (10^{12} floating point operations per second) level. Its other roles include evaluating experimental hardware for testbeds, supporting the development of the National Research and Education Network (NREN), promoting long-term research of the underlying theory and concepts of high performance-computing and increasing the pool of personnel trained to use HPCC technology.

NASA is the lead agency for coordinating plans to develop systems software and tools for the federal HPCC program. In April 1993, a workshop of experts from industry, academia and government will be convened to produce a national agenda for software and tools for high-performance computing applications. A technical report will summarize their findings, and this report will be used to help formulate a national perspective on systems software requirements. NASA also is leading federal efforts to make HPCC software less expensive and more robust by encouraging software sharing and reuse. In FY 1993, NASA has established an experimental software exchange system that connects software repositories across a number of federal agencies. A series of metrics has been developed to compare alternate architectures for future generations of the exchange system.

During FY 1993, significant progress has been made in the program including: awarding grants to multidisciplinary research teams to support the Earth and Space Sciences (ESS) project, and contributing to, and continuing to act as a member of the Concurrent Supercomputing Consortium for the use of Intel

Corporation's massively parallel Delta Touchstone supercomputer installed at the California Institute of Technology. Specific accomplishments include: generating 3-dimensional images of the planet Venus from Magellan satellite data; direct numerical simulation of large, time-dependent compressible Navier-Stokes equations; and 3-dimensional compressible turbulence simulations for high Reynolds numbers.

Single discipline computational fluid dynamics (CFD) codes were adapted for a number of massively parallel supercomputers including the Thinking Machines CM2 and Intel iPSC/860. These pilot fluid codes are being applied to both high-speed civil transport and high-performance aircraft applications. NASA also accomplished the benchmarking of multidisciplinary codes on parallel supercomputers, including the development and demonstration of a coupled aerodynamics and structures code on the Intel iPSC/860 supercomputer. Furthermore, NASA researchers have created methods for streamlining the process required for developing an optimal airframe design. The development of these codes complements the High-Speed Civil Transport (HSCT) program by allowing aircraft manufacturers to analyze different design options rapidly and produce vehicles more efficiently with optimal performance and reduced design cycle costs.

NASA researchers also have established a parallel computing testbed using a cluster of high-end IBM workstations. This testbed will provide for the early evaluation of clustered workstations for multidisciplinary aeropropulsion simulation.

NASA also contributed to the advancement of the National Research and Education Network by entering into a cooperative agreement with the Department of Energy to procure research network services based on emerging cell-switching technology that operates at 45 megabits per second (mbps). This is a vast increase over previous network services which only operate at 1.5 mbps. These interconnects are essential to connect NASA field centers at greater data exchange rates and provide industrial and university researchers access to NASA computing testbeds.

In addition, NASA made several contributions to the program's Basic Research and Human Resources component by funding in-house activities to develop advanced algorithms for multidisciplinary applications on parallel computing testbeds. It provided funding support for university efforts through NASA research institutes and provided funding for seven graduate student researchers. Finally, NASA advanced its outreach efforts for K-12 grade students by selecting two pilot high schools to begin the development of networking-supported research and education activities.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program was reduced by $5.0 million as a result of Congressional action on the FY 1993 budget request. This decrease has been accommodated in both the computational aerosciences and in the Earth and space sciences area. Some planned activities will be delayed or descoped to accommodate this reduction. This decrease was offset by the addition of $0.4 million resulting from the restructuring of Research Operations Support (ROS). The estimate does not reflect the approximately $4.7 million in additional funding requested in FY 1993 as part of President Clinton's economic stimulus package.

BASIS OF FY 1994 ESTIMATE

In FY 1994, NASA's HPCC program is focused on two areas of application: integrated, multidisciplinary computational aerospace vehicle design and multidisciplinary modeling and analysis of Earth and space science phenomena.

NASA plans to initiate activities to broaden the reach of the HPCC program and begin the development of a national information infrastructure by supporting research and development in education, digital library technology, manufacturing and design, and access to Earth and space science data. In education, NASA will increase its focus on developing K-12 education products available over the NREN and establishing teacher training programs for the utilization of NASA education products. In manufacturing and design, it will expand cooperative efforts with industry and academia for multidisciplinary design of aeronautical airframes and engines, and increase its reach to include other industrial sectors such as electronics and automotive. In digital library technology, NASA will advanced technology in petabytes data storage systems, full test retrieval, multimedia standards, classification guides and catalogues for scientific and technical information and visualization. NASA also will increase efforts to make Earth and space science data more widely available by developing and evaluating prototype digital data bases of images and software that are available over the NREN.

Grand Challenge software applications research will proceed in two distinct projects: the computational aerosciences (CAS) project and the Earth and space sciences (ESS) project. The CAS project will direct its efforts towards continuing the development of multidisciplinary algorithms and advanced software technology in two Grand Challenge areas. These areas are high speed civil transport (HSCT) and high-performance aircraft applications. The ESS project will focus on Grand Challenge teams selected in FY 1993 in the areas of: climate modeling; studying ocean, land and atmosphere dynamics; modeling magnetosphere-solar wind interactions, stellar interiors and surfaces, star/galaxy creation and evolution, and the formation of other cosmological structures; analyzing enormous geophysical databases; and the assimilation of atmospheric data.

Testbeds are a crucial part of this program because they provide a key tool for interdisciplinary research teams to develop and evaluate applications and systems software and to evaluate scalable hardware architectures and peripherals. A key to successful exploitation of massively parallel computing power will be the blending of application-driven and architecture-driven computer systems and software to most effectively meet NASA's needs. Second generation prototype testbeds of up to 20 gigaFLOPS are scheduled to become operational in FY 1994, with third generation testbeds of 50 to 200 gigaFLOPS set to become operational in FY 1996. These testbeds will not be replacements for the numerical aerodynamic simulation (NAS) system or any of NASA's other computational facilities, but rather will serve as proof-of-concept systems which could be used by those computing facilities once the systems are scaled up and ready for operational use.

NASA's needs for systems software in the FY 1994 timeframe and beyond are being framed by the NASA-led team in charge of coordinating federal systems software. To date, some of the needs that have been identified include: operating systems, compilers, programming environments and visualization software. Other important requirements include dynamic load balancing of processors in parallel and distributed systems and the development of operating systems which permit heterogeneous computing. Still other significant areas include programming languages and environments because they are the mechanisms which developers use to interface to high-performance computing systems.

Agency plans under the Basic Research and Human Resources Element include approximately doubling the number of graduate student researchers in the program. NASA plans also include identifying NASA-owned or controlled assets to deploy on the NREN for education, conducting workshops to develop K-12 assets and curricula and integrating its efforts with those of other federal agencies.

Finally, NASA's testbed systems must be hooked up to a nationwide research network to allow access by supporters of the federal HPCC program. Only in this fashion can applications developers have access to the broad range of architectures they require. NASA is meeting this requirement through its participation in the NREN. Agency NREN plans call for establishing 155 Mbps connections among NASA HPCC testbed sites in FY 1994 and upgrading that capability to 633 Mbps by FY 1996.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Materials and structures systems technology..........................	37.562	35.500	36.628	25.700*

* Advanced high-temperature engine materials ($10.523) transferred into the materials and structures portions of the research and technology base in FY 1994.

OBJECTIVES AND STATUS

The objective of the materials and structures systems technology program is to develop advanced materials and structural concepts for future advanced aircraft propulsion systems and primary structures. The program is conducted in two tasks. one focused on advanced high-temperature engine materials technology and the other focused on advanced composites technology for airframe structures.

The advanced high-temperature engine materials technology program is a focused laboratory-scale materials and structures research program with application to the complete range of aircraft propulsion systems. including rotorcraft. subsonic and supersonic transports. Major consideration is given to propulsion systems that will be friendly to the environment in terms of minimizing pollution and noise. and that will be economical via reducing fuel consumption and direct operating costs while extending life and improving reliability. These goals require very high thrust-to-weight (20 to 1) gas turbine engines with durable. long-life. high-temperature components. Key to these applications are ceramic matrix composites (CMC's). metal matrix composites (MMC's). intermetallic matrix composites (IMC's). and polymer matrix composites (PMC's) which can endure sustained operation at elevated temperatures. Advanced analysis. design and life prediction methods are being developed for these materials to provide an understanding of composite architecture. processing. fiber/matrix interaction. and failure mechanisms at temperatures up to 3000 degrees Fahrenheit. Supporting technologies are also being developed in the areas of high-temperature instrumentation. nondestructive evaluation (NDE). and aerodynamic/thermodynamic loads definition. During FY 1993. the advanced high-temperature engine materials element is continuing the development and characterization of high-temperature PMC's. IMC's. and CMC's. High molecular weight polymers are being evaluated for high-temperature PMC's. IMC efforts continue to focus on development and demonstration of fibers and fiber coatings. optimization and demonstration of composite fabrication processes. and development and verification of analytical and NDE methods. CMC efforts are concentrating on: development of small-diameter ceramic fibers/coatings that are stronger and more creep resistant than current fibers: continued investigations into the environmental and microstructural factors limiting CMC use temperature and life: development and verification of analytical methods for predicting the reliability of CMC structures:

and the development and demonstration of high-temperature test methods and NDE methods. Technology transfer will continue to be addressed through cooperative efforts with the major U.S. turbine engine manufacturers. A fiber sizing that will withstand use temperatures of 700 to 800 degrees Fahrenheit will be verified through an engine core test of a high-temperature PMC actuation ring. Oxidation-resistant coatings for CMC's will undergo engine testing in a turbine shroud application.

The objective of the advanced composite materials systems technology program is to develop innovative cost-effective structural concepts and fabrication processes to more fully exploit the advantages of composite materials in primary structures of future aircraft. While the current demonstrated level of composites technology can promise improved aircraft performance through reduced structural weight, it does so at an inhibiting increased cost. Further development of the technology is pursued through material formulation and processing refinements, innovative fabrication concepts with their resulting unique structural configurations, and analytical developments for improved structural behavior prediction. The improved technology levels will be demonstrated and validated by fabrication and testing at the subcomponent and subscale component levels. Such validation is an essential building block leading to full-scale primary structures. The program goals are to develop technology that will reduce airframe structure acquisition costs by 25 percent and structural weight by 30 to 50 percent, after resizing the aircraft for maximum benefit. To achieve these goals, a new approach to composite design must be developed by integrating the design concepts with advanced fabrication techniques using new material forms. Understanding of failure mechanisms and behavior under complex loadings is critical to establishing the data base for innovative design with composites. The new structural concepts, (advanced fiber placement, woven textile preforms, and resin transfer molding), continue to show potential for achieving cost-effective composite primary aircraft structures. A fuselage crown panel fabricated by advanced fiber placement has been successfully demonstrated. Compared to equivalent metal crown panel structures, the composite panel design is estimated to be 30-percent lighter and 20-percent less expensive to build. Tests will measure the structural performance of this design under selected loading conditions in the presence of various types of damage. One panel will be damaged and then repaired by a major airline prior to structural testing. Woven preforms based on technology borrowed from the textile industry show promise for major subcomponents of fuselage panels including frames, window belts, and keel beam/frame intersections. The two- and three-dimensional braiding techniques applied to window belts showed the most potential for cost savings while maximizing the strength advantages offered by composites. Progress continues in the development of a new stitching machine. Two 4x5-foot stiffened wing panels, which were fabricated using stitched preforms and the resin transfer molding process, were successfully tested under compression loading with induced damage. Good progress is being made in analytical methods development to support the design of composite wings and fuselages. The third technical conference, held to disseminate results to airframe manufacturers and materials suppliers, was well attended and the fourth conference is scheduled for June 1993.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program reflects a net increase of $1.1 million as a result of the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

In FY 1994, the advanced high-temperature engine materials technology program has been transferred into the materials and structures portion of the research and technology base.

During FY 1994, in the advanced composites technology program, development of design and manufacturing techniques for composite fuselage subcomponents and full-scale wing_components will continue with a significant emphasis on verification testing. Validation of the fuselage keel damage tolerance and load redistribution will be completed. Testing of the woven textile frames and window belts and development of innovative tooling and requirements for a weaving machine will be completed. Testing will continue on the fuselage side panels to ensure the pressure load is properly distributed about the windows. Testing will begin to assess the load transfer across the major intersection between the fuselage crown and side panels. Completion of benchmark tests for fuselage panels to verify the analytical methods will allow prediction of the behavior of a full-scale fuselage. A cost model developed under this effort will be exercised to predict the cost and weight of the fuselage. Major milestones in the development of the composite wing will also be reached during FY 1994. These milestones include wing subcomponents design, fabrication and testing; tooling design, fabrication and checkout; and the design of a full-scale semispan composite wing box. Completion of development of RTM/stitching technologies in FY 1994 will enable initiation of fabrication of the wing box. The experimental characterization of the mechanical properties, damage tolerance and fatigue response of RTM-type resins and laminate architectures of woven and stitched preforms will be completed. The advanced stitching equipment will be constructed. The fifth technical conference will be held to ensure continued dissemination of the technology to airframe manufacturers and materials suppliers.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Rotorcraft systems technology..........	4,900	5,400	6,977	

* Advanced rotorcraft ($5,280) transferred into the aerodynamics portion of the research and technology base in FY 1994.

OBJECTIVES AND STATUS

The rotorcraft systems technology program is focused on developing technologies for rotorcraft noise reduction and for tiltrotor aircraft.

Noise reduction was identified by NASA as the highest priority research area in tiltrotor aircraft. Simulations of steep approaches for noise abatement are being made to define the envelope to be evaluated in flight tests with the XV-15. The design and fabrication of the tiltrotor aeroacoustic model (TRAM), started in 1992, is being continued. That model is to be used for detailed airloads and acoustic testing in low-noise wind tunnels when complete in 1994.

Several promising innovative concepts for noise reduction are being evaluated in numerical studies. The compromises presented by each, in terms of complexity, performance, and noise reduction, are being evaluated to determine which concepts will be carried forward to small-scale wind tunnel tests. The results of those tests, also scheduled for 1994, and computational analysis will determine which concepts will be carried to full-scale evaluation.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program was increased by a total of $1.6 million, including $1.3 million for civil tiltrotor technology as a result of Congressional action on the FY 1993 budget request and $0.3 million resulting from the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

Rotorcraft aeroacoustics and high-speed rotorcraft are being moved from systems technology to the aerodynamics portion of the research and technology base.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
High-performance aircraft systems technology........................	10,700	11,900	12,070	*

* High-performance flight research ($9,570) transferred into the flight systems portion of the research and technology base in FY 1994.

OBJECTIVES AND STATUS

This program generates validated methods and design data applicable to the development of advanced high-performance aircraft applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel testing, and flight research involving tests of advanced aircraft concepts and systems. The high angle-of-attack research program is obtaining a flight-validated data base for design of highly agile aircraft. The F-18 high angle-of-attack research vehicle (HARV), equipped with the thrust vectoring control system (TVCS), completed envelope expansion. The flight evaluation of the baseline TVCS control laws has been completed and the first set of advanced control laws has been installed and is in the process of flight evaluation. The F-15, with highly integrated digital electronics controls, continues to demonstrate the capability to actively determine and adjust critical engine and flight control parameters with real-time parameter estimation methods. Substantial improvement to the specific fuel consumption and aircraft performance at both subsonic and supersonic speeds has been demonstrated. The program has also demonstrated a very significant increase in the engine life throughout the full flight envelope by reducing engine temperatures while maintaining thrust. The vertical/short takeoff and landing (V/STOL) research aircraft YAV-8B Harrier flight research program investigates guidance/display schemes, and integrated flight and propulsion concepts for the hover and transition flight regimes. The modification to the propulsion control system of the V/STOL research aircraft is nearly completed, providing a highly versatile, digitally implemented longitudinal and propulsion control system to properly support the continuing investigations critical to all future V/STOL designs. Initial system integrity flights will be accomplished in FY 1993. Two F-16XL testbed aircraft are on loan from the Air Force to support high-speed research. One aircraft has completed an initial laminar flow experiment that established the feasibility of achieving laminar flow at supersonic speed. The second aircraft has been used to gather fundamental information necessary to design a more definitive supersonic laminar flow experiment dedicated to the systematic investigation of supersonic laminar flow control devices including a passive leading-edge glove to obtain attachment line criteria, surface pressure and transition data for code calibration, and transition prediction technique improvements.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program was increased by $0.2 million as a result of the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

The high-performance aircraft systems technology activities are being transferred to the flight systems portion of the research and technology base.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced propulsion systems technology........................	15,180	16,000	16,900	

* General aviation/commuter engine technology ($3,085) transferred into the materials and structures portion of the research and technology base, and advanced turboprop systems ($15,246) transferred into advanced subsonic technology in FY 1994.

OBJECTIVES AND STATUS

The objective of the advanced propulsion systems technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components.

The advanced turboprop systems program is directed toward establishing low-noise, high-bypass concepts and providing the broad research and technology data base necessary for achieving maximum source noise reduction for subsonic propulsion systems. In FY 1993, the advanced turboprop program is focused on the noise reduction of high-bypass ratio engines. The program will select an optimum low-noise concept and cycle which includes consideration of engine airframe integration while maintaining high levels of engine performance. Preliminary testing of the advanced fan and nacelle concepts will be initiated. The engine source noise reduction will positively impact the U.S. aircraft industry's competitiveness in the global market as international noise standards become more stringent in the future.

In the general aviation/commuter engine technology program, the objectives are to raise the performance level of small turbine engines to approximately that of large transport turbine engines, with a decrease in fuel consumption. Propulsion efficiency research will be focused on developing an understanding of governing flow phenomena in small-size turbomachines at the component level. The work will be focused on providing a detailed understanding of the design parameters that affect component performance through the development of analytical codes and the associated experimental data base for validation. In FY 1993, the research emphasis will shift from radial inflow turbine concepts toward axial compressor technology. The performance testing of a multistage axial compressor with realistic tip clearances will be initiated. In-depth experimental evaluation of axial compressors will provide an understanding of mixing phenomena, which control the performance of multistage compressors, used in small turboshaft engines and large turbofans.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program was increased by $0.9 million as a result of the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

In FY 1994, the advanced turboprop systems program will be transferred to advanced subsonic technology as the noise reduction element to more appropriately reflect the nature of the work. The general aviation/commuter engine technology effort will be transferred into the materials and structures portion of the research and technology base.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Numerical aerodynamic simulation.......	45,400	47,000	47,930	49,100

OBJECTIVES AND STATUS

The numerical aerodynamic simulation (NAS) program objective is to significantly augment the Nation's capabilities in computational fluid dynamics (CFD) and other areas of fluid physics by developing a preeminent capability for the numerical simulation of aerodynamic flows. The NAS system continues its national operation by closely associating with and providing resources to other NASA programs, the Department of Defense (DOD), other Government agencies, industry and academia. This program provides the computing power which may not be available from other NASA computing facilities. The NAS facility provides the tools and resources dedicated to obtaining solutions to problems which may be intractable on less than state-of-the-art computer systems, including solutions to the Navier-Stokes equations (enabling performance analysis predictions for complex aircraft geometries). In order to ensure this degree of computational capability, the NAS program continues to implement the following efforts: (1) acquire pathfinding, state-of-the-art, high-speed processors (HSP's); (2) provide a uniform, balanced, user-friendly system with equivalent capabilities for local and remote users; (3) maintain an auxiliary processing center for secure processing; (4) research existing parallel architectures and incorporate them into future generations of the NAS; (5) develop a hardware and software environment for prototyping and testing of computers, networks, storage devices, workstations and graphic output devices; and (6) research and enhance an increasingly sophisticated system of hardware/software tools and environments to assist the user in performing CFD tasks efficiently.

During FY 1993, balanced system software and support for the HSP's are being achieved through a continuous upgrade process. The third high-speed processor (HSP-3), which replaces the original machine (HSP-1), will be placed in operation in March 1993. HSP-1 was returned to Cray Research as part of the negotiated contract for HSP-3 ($2.0 million credit to the HSP-3 contract). HSP-2 (a Cray Y-MP) was purchased completely in October 1992 (lease buyout option). HSP-3 will provide a fourfold increase in computational hours available to the NAS community. Mass storage capacity is 9.6 terabytes, enabling quickly available data storage consistent with HSP output capability. The AERONET, which links NAS capabilities to its customers, is operational. AERONET is the long-haul communications network which replaced older, switched networking with a newer routed (more reliable and efficient) network and increased traffic throughput speed by up to a factor of ten. The next generation workstation (WKS-III) request for proposal will be released in March 1993. The WKS-III is to provide a threefold improvement in workstation interface capability to the HSP's in FY 1994. To meet the challenge of providing increased operational computing capability for aerospace applications, pathfinding research

continues in parallel architectures and algorithms with mapping of specific aerodynamic simulation problems onto advanced computational platforms. The two NAS parallel machines are being upgraded from a Thinking Machines CM-2 to CM-5, and Intel Gamma to Paragon. During FY 1993, user interface and visualization software research emphasis is shifting toward multidisciplinary tools and requirements.

CHANGES FROM FY 1993 BUDGET ESTIMATE

This program reflects an increase of $0.9 million which resulted from the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

The number of accounts will be maintained around its current level (about 2000) continuing the diverse use of the system by NASA, the DOD, other Government agencies, industry and academia. During FY 1994, the next generation workstation (WKS-III) will be installed and become operational. The request for proposal for the fourth high-speed processor (HSP-4) will be released in FY 1994. HSP-4 is expected to provide another fourfold increase in capability over HSP-3. Other hardware and software elements of the extended operational configuration will continue to be enhanced as part of the continual process for development of future versions of the NAS.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
High-speed research....................	76,400	89,900	116,995	187,200

OBJECTIVES AND STATUS

Industry studies here and abroad have identified a substantial market for a future high-speed civil transport (HSCT) aircraft to meet the rapidly growing long-haul market, particularly the Pacific-rim sector where travel is projected to increase fourfold by the year 2000. Over the period from 2000 to 2015, industry estimates this market could support an estimated 500 to 1000 HSCT aircraft, thereby creating a multibillion dollar sales opportunity for its producers. While current technology is insufficient, the studies further indicate that an environmentally compatible and economically competitive HSCT could reach fruition through aggressive technology development and application. NASA's high-speed research program is providing a public-sector catalyst in addressing this important opportunity with U.S. industry through a two-phased approach. In order to ensure the commercial relevance of this program, a cost-shared partnership between NASA and industry will be sought wherever possible. Moreover, a program evaluation plan will be developed to identify timely independent reviews.

Phase I, a seven-year effort which began in FY 1990, is defining critical HSCT environmental compatibility requirements in the areas of atmospheric effects and community noise and sonic boom, and is establishing a technology foundation to meet these requirements. Progress to date has provided growing confidence that the necessary technology can be developed to satisfy the critical concerns. Most importantly, assessment results from the latest atmospheric models incorporating multiphase chemistry are now indicating that a fleet of 600 Mach 2.4 HSCT aircraft with advanced low-emission engines would cause virtually no impact in stratospheric ozone. In FY 1993, an interim assessment of the atmospheric effects of stratospheric aircraft is being submitted to the National Research Council for a critical review. The assessment is based on improvements of chemistry and dynamics simulations incorporated in the related atmospheric models. Flight tests of the Perseus autonomous aircraft will also be completed and two aircraft will be delivered for use in atmospheric measurement to continue the improvement and validation of the models.

Related laboratory testing of low-emission combustor concepts has also successfully achieved the desired reduced emission levels, with results even better than the program goal of five grams of nitrogen oxide (NOx) per kilogram of fuel. During FY 1993, the knowledge gained from this flame-tube level testing is being transferred to practical-application combustor sector hardware for experimental evaluation. Based on the results, configurations will be selected for both the lean premixed prevaporized and rich burn, quick quench, lean burn concepts to proceed with the verification of NOx reduction goals in full annular rigs that combine all of the similar components of an actual engine combustor.

In noise reduction, upwards of 18-decibel noise suppression has been achieved through advanced mixer-ejector nozzles, and wind tunnel testing of innovative high-lift devices shows an additional two- to six-decibel potential through advanced operational procedures. As a nominal, 20-decibel reduction is needed to achieve levels equivalent to the same stringent Federal Air Regulation 36 (FAR 36), Stage 3 noise standards required for today's new subsonic transport aircraft. There is growing confidence that community noise concerns can be satisfied. Testing of second-generation mixer/ejector nozzles, incorporating aerodynamic refinements and parallel acoustic treatment development, is continuing during FY 1993 to ensure the best selection of the top two engine configurations on an integrated noise and performance basis. Similarly, high-lift concept development is continuing to maximize its role in reducing aircraft system noise propagated to the community.

Although unlimited supersonic operation over land appears economically impractical based on wind tunnel model testing to date, the test results have shown the ability to soften the sonic boom with minimal penalty in aerodynamic efficiency. Small-scale aircraft model testing is thus continuing in FY 1993, but with a redirected objective of optimizing the performance of a configuration that could operate at Mach 1.6 to 2.4 along limited flight corridors over unpopulated regions.

Enabling propulsion materials research, initiated in FY 1992 to meet the requirements of high-temperature, low-emission combustors and low-noise exhaust nozzles, continues to focus on development of advanced ceramic matrix composite (CMC), metal matrix composite (MMC), and intermetallic matrix composite (IMC) materials. Primary and alternate combustor CMC materials have been selected and are being tested for mechanical and physical properties. Promising nondestructive evaluation (NDE) methods are also being assessed for their usefulness in characterizing the thermal-mechanical degradation of these CMC materials. In addition, coating requirements are being established for the combustor materials, and several coating approaches are under development. Primary and alternate nozzle IMC and MMC materials are also being assessed, and fiber/coating scale-up requirements and test methods are being defined. Analytical methods development continues to focus on heat transfer, constitutive and damage models, and life prediction methods. New high-temperature test systems which will provide unique capabilities for benchmark testing and long-term durability testing of combustor and nozzle materials are being installed and calibrated.

Based on this progress, the program has been expanded in FY 1993 to begin addressing the remaining technologies necessary to help the U.S. industry's competitive position to design an HSCT for operational introduction in the 2005 time frame. The objective of these Phase II efforts is to develop, in cooperation with U.S. industry, the high-leverage technologies also essential to economic viability. The $25 million added by Congress to the high-speed research FY 1993 budget has enabled initiation of the longest-lead, most critical Phase II areas -- advanced high-temperature, long-life materials for key airframe structures, and propulsion components for high fuel efficiency, as well as low noise and emissions. Key FY 1993 efforts include design and integration studies to assess the benefits and risks of advanced materials, structural concepts, and manufacturing approaches; development of a common set of structural design requirements and

baseline designs for both Mach 2.0 and Mach 2.4 aircraft, including a common data base of material property requirements: and development of both metallic materials (aluminum and titanium) and polymer matrix composites (PMC's), including initiation of long-term durability testing.

CHANGES FROM FY 1993 BUDGET ESTIMATE

High-speed research reflects a $27.1 million increase, $25.0 million of which resulted from Congressional action. As described above, this is being used to augment the ongoing program to initiate the highest priority areas in propulsion and airframe technology necessary for timely HSCT technology development. An additional $2.1 million was reallocated to this program as part of the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

With the full initiation of Phase II in FY 1994, the high-speed research program will be addressing the essential technologies needed by the U.S. aeronautics industry in order to make informed decisions regarding future HSCT development and production. Phase II is planned as an eight year effort. The technology foundation necessary to resolve critical environmental compatibility issues will continue to be developed, and will be complemented by additional efforts to also ensure economic viability.

Improved understanding of the atmospheric effects of stratospheric aircraft remains as a key area of emphasis in FY 1994. In collaboration with the airborne southern hemisphere ozone expedition, additional atmospheric measurements will be obtained for different latitudes than previously studied, including equatorial regions. New instruments developed for improved understanding of recent important heterogeneous chemistry hypotheses will be applied on the ER-2 aircraft platform, as well as on the first field deployment of the Perseus autonomous aircraft. The atmospheric modeling effort will emphasize evaluation of uncertainty in continuing assessments of aircraft effects on ozone and a first assessment of climatic effects. Recommendations from the FY 1993 National Research Council review of interim assessment activity will also be implemented as appropriate.

Propulsion component technology will be expanded in FY 1994 by building on the emissions and source noise reduction research, and by also increasing the efforts started in FY 1993 on high-performance inlets and fans. The lean premixed prevaporized and rich burn, quick quench, lean burn combustor flame-tube and sector rig test results will be used to begin the design of full annular combustor rigs for later testing to validate the low NOx capability for stable and efficient operation over the full range of conditions from startup, taxi and takeoff, through climbout, cruise and landing. In a parallel effort, preliminary design will begin for combustor experiments with a testbed engine. A second generation of model mixer/ejector nozzles will be evaluated in coordination with primary and backup engine selections that promise acceptable community noise levels and economical performance. Special consideration will be given to ejector acoustic liners to reduce mixing noise. The small-scale test results and supporting analyses will be used to begin

preliminary design of the two best nozzle concepts for large-scale experiments with testbed engines over the projected full range of operating conditions. Engine inlet technology will similarly be advanced with small-scale tests. In particular, the two-dimensional bifurcated inlet development will be initiated to bring this concept to the same level of maturity as the axisymmetric concept. A preliminary design of a high-flow fan will also be conducted.

Enabling propulsion materials development will continue to focus on combustor liner CMC's and nozzle IMC's and MMC's. The first annual technical program review will be conducted with industry participants in the spring, at which time progress in the development of primary and alternate combustor liner materials and design concepts will be assessed. Primary and alternate nozzle materials and design concepts will be selected in the summer based on design studies and characterization tests conducted over the past year. Scale-up of the primary CMC and IMC fiber/coating processes will be started, and the most promising CMC materials will be selected for component fabrication and test. Material selections will continue to be assessed on an ongoing basis as the requirements become better defined by the propulsion system trade studies.

Because of the durability challenges facing successful use of PMC's in high-temperature applications, initial efforts are focused on long-term durability testing of promising materials and on development of accelerated test methods. In addition, commercial and developmental polymers are being modified and evaluated for mechanical properties, durability, and processability. An assessment of low-cost processing methods for both metals and composites will also be initiated. Superplastic forming/diffusion bonding, laser welding, and brazing/diffusion bonding will be evaluated for producing low cost advanced titanium structures, and low cost forming and joining processes such as adhesive bonding, weld bonding, and rivet bonding will be evaluated for advanced high-temperature aluminum structures. Candidate composite materials will be assessed for their amenability to automated tape and tow placement, resin transfer molding, and thermoforming techniques, and the most promising high-temperature polymers will be developed as adhesives.

The airframe materials and structures technology effort will continue to focus on development and evaluation of both high-temperature metallic materials (aluminum and titanium) and PMC's. The focus in metallic materials is on promising new low-density and high-temperature aluminum alloys for use up to Mach 2.0, and on advanced titanium alloys (for use up to Mach 2.4) which offer specific properties that are 20-percent higher than conventional titaniums.

Aerodynamics technology efforts will be expanded by initiating wind tunnel testing of baseline aircraft design at transonic and supersonic conditions. Following these tests, computational analysis will be used to optimize the total wing-body configuration, including propulsion system integration, to evolve a second-generation design. In parallel, analytical and wind tunnel evaluations of low-boom, high-performance configurations will be conducted, and the assessment of human response to in-home exposure to simulated sonic booms will be completed. High-lift concept development will continue with computational and

experimental aerodynamic evaluations and assessment of the associated noise reduction. The most promising high-lift concepts will be readied for high-Reynolds number wind tunnel testing in the National Transonic Facility. Using knowledge gained from previous supersonic laminar flow flight research, the large suction panel for active aerodynamic control will be fabricated for planned flight testing on the F-16XL testbed in FY 1995.

Flight deck systems research and technology development will be initiated in FY 1994 to also provide for safe and efficient integration of a future HSCT in the international air transportation system. First-year efforts will concentrate on pilot information requirements and advanced cockpit displays for both the synthetic vision and flight management systems. Modeling of the HSCT aerodynamics, structural modes, and flight and propulsion controls will also begin in support of ground-based and in-flight simulations to be used throughout the development process in evaluating overall flying qualities.

Because of the high level of interdependency between the above technologies, system-level integration studies will continue in order to assure that environmental goals can be achieved in concert with economic viability.

Due to the continuing need for an instrument platform with greater altitude, duration and range capability, a technology program for unmanned aerospace vehicles will be initiated. Emphasis will be on propulsion systems suitable for operation in the rarefied upper atmosphere.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced subsonic technology..........	5,000	12,300	12,425	101,300

OBJECTIVES AND STATUS

With competition from foreign competitors greatly increasing, technology is critically needed to help preserve the U.S. aeronautics industry market share, jobs, and balance of trade. Exports in large commercial transports make a significant contribution to the U.S. balance of trade. However, industry estimates that the U.S. world-wide market share has slipped from a high of 91 percent during the 1960's to 67 percent in 1992. Increasing congestion in the aviation system and growing concerns about the environmental compatibility of aircraft may limit the projected growth in the market. According to the Federal Aviation Administration (FAA) 1991-1992 Aviation System Capacity Plan, delays due to weather and the volume of aircraft in the Air Traffic Control System cost U.S. operators more than $4.7 billion per year in excess fuel burn and additional operational costs during 1990. Noise curfews and inefficient engine emissions standards are expected to be required before the end of this century. In FY 1994, the Advances Subsonic Technology program will accelerate the broad-based NASA R&T program for subsonic aircraft by augmenting the focused development of high payoff technologies to enable a safe, highly productive global air transportation system that includes a new generation of environmentally compatible, economical aircraft that are superior to foreign products. In order to ensure the commercial relevance of this program for those projects benefiting industry, a cost shared partnership between NASA and industry will be sought wherever possible. Moreover, a program evaluation plan will be developed to identify timely independent reviews. The fly-by-light/power-by-wire (FBL/PBW) and aging aircraft elements began in FY 1992.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The advanced subsonic technology program reflects an increase of $0.1 million which resulted from the redistribution of ROS funds.

BASIS OF FY 1994 ESTIMATE

The advanced turboprop program (ATP), now focused solely on noise reduction, will be moved to Advanced Subsonic Technology (AST) and renamed as the noise reduction element. This element will be augmented beginning in FY 1994. The terminal area productivity (TAP), integrated wing design, propulsion, short-haul aircraft technology integration and environmental impact and environmental research aircraft and remote sensor technology elements will be initiated in FY 1994.

The ongoing FBL/PBW element is emphasizing development of analytical and experimental methods for assessing electromagnetic effects. In FY 1994, an experimental laboratory will be completed where analytical methods can be validated. Laboratory testing of critical optical and power components will be initiated in FY 1994.

During FY 1994, the ongoing aging aircraft program will complete the development of computational methods to predict multisite fatigue crack growth and the residual strength of aluminum airplane fuselages. Also in FY 1994, experimental validation of these methods will continue, and two NDE techniques used on large fuselage surface areas will be verified.

In FY 1994, the emphasis in noise reduction will continue to be the understanding and control of source noise mechanisms, propulsion/airframe installation aerodynamics, and the development of improved aerodynamic, structural and acoustic analysis techniques for ultra-high bypass subsonic propulsion systems. Testing and validation of selected fan and nacelle configurations addressing the impact of engine/airframe integration will be completed. The FY 1994 augmented effort will include validation of an aerodynamic and performance design code, definition of baseline engine noise sources, demonstration of active noise reduction concepts for a selected nacelle configuration, evaluation of novel installation concepts, and assessment of current airframe noise prediction capabilities.

In FY 1994, the terminal area productivity element will be initiated and will evaluate the potential for ground-to-aircraft data communications and dynamic spacing capabilities based on NASA's air traffic control automation efforts. Reduced separation requirements will be investigated by evaluating wake vortex issues and community noise constraints, as well as enhanced aircraft flight management systems.

The integrated wing program, to be initiated in FY 1994, will focus on technology that treats the aircraft aerodynamics in an integrated manner. In 1994, transport flight test data will be used to validate computational codes for the evaluation of high-lift systems. Additionally, a semispan, large-scale transonic wind tunnel test will evaluate propulsion airframe integration. This effort will build upon and integrate the fundamental concepts and component technologies being addressed in the propulsion and power research and technology base program.

Within the short-haul aircraft element being initiated in FY 1994, tiltrotor tests will be conducted utilizing the XV-15 and vertical motion simulator to determine noise characteristics and to investigate the terminal area flight procedures that can be employed to control the radiated noise patterns. Also in FY 1994, wind tunnel tests and computational studies on integrated aerodynamics and structural concepts for a new class of short-haul aircraft will be undertaken. New cockpit technology for this class of aircraft will be initiated.

In FY 1994, the advanced propulsion element will be initiated and will focus on establishing specific engine concepts and configurations which reflect industry's vision of the next-generation high-bypass-ratio turbofans.

Systems analyses efforts to be initiated in FY 1994 within the technology integration and environmental impact element will establish an integration team and framework for integrating analytical methods. In-house modeling capabilities for aircraft, engines and air traffic control economics will be improved. An initial systems analysis will be performed to assess technology status and impact integrated aviation system components. The scientific modeling and assessment effort underway for aircraft emissions into the stratosphere will be expanded to include upper troposphere altitudes typical for subsonic transport operations. This effort will include development of advanced instrumentation and remote sensor technology for use on existing and new research aircraft. The composites element will be initiated in FY 1995. All projects have identified end dates so to enable the possibility of new promising technology projects.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Research operations support...........	232.800	243.200	148.875	143.500

OBJECTIVES AND STATUS

Research Operations Support (ROS) funding provides vital support to the civil service workforce and to the physical plant at the Centers and at NASA Headquarters. This funding supports the basic core administrative functions such as personnel. payroll. accounting. procurement and legal counsel. It also supports centerwide services for civil service staff. such as mail. telephones. janitorial services. transportation. medical (other than astronaut). security. and fire protection. as well as maintenance of roads. grounds. and all requirements of administrative buildings. Funding to support activities which directly benefit all NASA programs is included in the program budgets.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1992. establishment of the ROS was initially accomplished by transferring funds contained in the Operation of Installation account in the Research and Program Management appropriation to the Research and Development and Space Flight. Control and Data Communications appropriations. During FY 1993. a more detailed examination of activities supported by ROS funding was conducted by the program offices to identify those directly related to programmatic activities. Funding for activities dedicated to a single program was transferred to the benefiting program. In total. the decrease in ROS funding reflects the transfer of $82.3 million consistent with the restructuring activity and a reduction of $14.3 million consistent with Congressional direction to reduce ROS. which has been partially offset by the addition of $2.3 million for financial management system upgrades at the Ames. Langley. and Lewis Research Centers.

BASIS OF FY 1994 ESTIMATE

The FY 1994 estimate reflects the necessary funding to support administrative and facility maintenance requirements at the NASA Centers and NASA Headquarters. This includes administrative services that support allcivil service employees. facility maintenance. maintenance of roads. grounds and requirements of administrative buildings.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Transatmospheric research and technology	4,136	80,000	--	80,000	RD 10-2
Distribution of Program Amount by Installation					
Ames Research Center	901	2,400	--	4,000	
Langley Research Center	2,250	4,800	--	7,000	
Lewis Research Center	893	3,200	--	5,000	
Marshall Space Flight Center	10	100	--	--	
Headquarters	82	69,500	--	64,000	
Total..........................	4,136	80,000	--	80,000	

OBJECTIVES AND JUSTIFICATION

The Transatmospheric Research and Technology program is the NASA portion of the joint NASA/Department of Defense (DOD) National Aero-Space Plane (NASP) program. The program objective is to develop and then demonstrate the technology required to permit the Nation to develop reusable, single-stage-to-orbit (SSTO) vehicles with airbreathing primary propulsion as well as horizontal takeoff and landing. The extremely short duration, non-real gas test conditions available in hypersonic ground test facilities cause considerable uncertainty about very high Mach hypersonic flight, especially scramjet engine performance. To reduce technology risk hypersonic flight experiments are being examined to validate ground-based computational and wind tunnel data.

The exceptionally broad technology base includes propulsion, materials and structures, control, and applications of computational fluid dynamics. High-risk program elements (primarily aeropropulsion) and hypersonic flight tests of critical technology elements are the near-term focus.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The NASA FY 1993 Transatmospheric Research and Technology program funding was removed (without prejudice) by the Congress. Consequently, the program was restructured, using DOD funding, to begin focusing more on the hypersonic propulsion system, the highest risk area. DOD funds were also used in FY 1993 to support the execution of a variety of critical technology development tasks at NASA Centers.

BASIS OF FY 1994 ESTIMATE

During 1994, ground-based testing of the ramjet/scramjet concept development engine (CDE) will continue at the NASA Langley Research Center, and will focus on propulsion technologies and the initiation of hypersonic flight test experiments such as rocket boosted experiments. A series of specific technology-development tasks assigned to NASA Research Centers will continue to utilize the unique expertise of NASA personnel; in other areas, NASA will continue to support technology-development tests by contractors in its facilities.

Work on propulsion will grow to include more sophisticated tests of refined engine components and more complete engine models. Ground tests of large-scale engine models will provide key data for equivalent flight speeds of up to Mach 8 in FY 1994. In preparation for hypersonic flight experiments, component tests will be pursued at simulated flight speeds of Mach 18. Such tests will provide the performance for data for engine-cycle concepts in scramjet, as well as ramjet-to-scramjet transition modes, for the engine configuration which will be tested during the subsequent flight experiments. Work on engine materials and structures, including actively cooled sections and engine aeroelastic behavior, will lead to refinements in the scramjet engine design.

Airframe work will focus on documentation of the initial airframe design, advanced materials characterization and large-scale structural tests in support of hypersonic flight experiments. Lightweight metal-matrix composites will be more completely characterized. Thermo-mechanical tests of fuselage panels and actively cooled assemblies, which will be subjected to many cycles of simulated hypersonic flight conditions, will be completed. Key test data will be provided on flight experiment engine/airframe integration.

Computational fluid dynamics (CFD) will continue to play a vital role in both external and internal (propulsion-type) flows. CFD advancement in FY 1994 will further augment design/analysis processes for complex flows such as those found in the scramjet combustor.

Initial work will be aimed at flight experiments to reduce technological risk in the prediction of both hypersonic boundary-layer transition (laminar-to-turbulent) and of scramjet performance. A number of flight tests are likely. Concept design, systems operations, instrumentation and other activities will be pursued to support initial hypersonic flight experiments

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SAFETY AND MISSION QUALITY — SAFETY, RELIABILITY, MAINTAINABILITY AND QUALITY ASSURANCE

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Safety, reliability, maintainability and quality assurance	33,600	32,500	32,707	35,300	RD 11-2
Total	33,600	32,500	32,707	35,300	
Distribution of Program Amount by Installation					
Johnson Space Center	3,914	2,260	2,936	2,140	
Kennedy Space Center	1,818	1,925	1,101	1,925	
Marshall Space Flight Center	2,636	1,895	2,059	1,660	
Stennis Space Center	620	860	713	480	
Goddard Space Flight Center	4,268	3,270	4,591	2,771	
Jet Propulsion Laboratory	5,370	4,389	3,126	1,390	
Ames Research Center	150	271	221	350	
Langley Research Center	2,282	1,665	2,107	2,066	
Lewis Research Center	4,232	3,480	3,982	4,136	
Headquarters	8,310	12,485	11,871	18,382	
Total	33,600	32,500	32,707	35,300	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

OFFICE OF SAFETY AND MISSION QUALITY — **SAFETY, RELIABILITY, MAINTAINABILITY AND QUALITY ASSURANCE**

OBJECTIVES AND JUSTIFICATION

The goal of the Office of Safety and Mission Quality (OSMQ) is to assure the safety and quality of NASA missions. This is achieved through the development, implementation, and oversight of Agencywide safety, reliability, maintainability, and quality assurance (SRM&QA) policies and procedures. In addition, OSMQ conducts independent technical assessments of all major flight and nonflight projects to determine compliance to SRM&QA requirements. The SRM&QA functions include program assurance: development of technical standards and demonstration of key technologies for improving program assurance: safety: systems assessments and trend analyses: risk identification and resolution: reliability, maintainability, and quality assurance: and quality management initiatives.

OSMQ is dedicated to conducting NASA programs within an acceptable level of risk and providing NASA leadership in quality management of science and engineering programs.

The objectives of the NASA OSMQ are to:

- Coordinate the activities of NASA's SRM&QA offices, providing advice to the Administrator on key safety and mission assurance issues.

- Develop and implement NASA-wide risk management practices.

- Integrate SRM&QA requirements at the earliest possible stage of a program or project.

- Develop and advance engineering and SRM&QA standards and practices.

- Provide NASA leadership for the development of software independent verification and validation (IV&V) techniques.

- Develop and advance SRM&QA presence in NASA programs and operations.

- Serve as an advocate for NASA-wide SRM&QA functions.

The office is involved across all levels of NASA programs to provide SRM&QA leadership. A key function is to provide independent judgments of program decisions and issues based on SRM&QA analyses, particularly where there is divergent engineering opinion on critical points or a high degree of uncertainty that could impact program safety and mission success. OSMQ ensures that SRM&QA requirements are integrated into the earliest phases of development for space and aeronautics programs. Conformance with SRM&QA policies and procedures is monitored through each program phase to assure proper attention to risk. Through SRM&QA surveys and Functional Management Reviews (FMR's) of the NASA Centers, SRM&QA program implementation is assessed.

In the area of Safety, OSMQ develops top-level safety policies, defines program-specific safety requirements, and identifies risks. A primary means of supporting the NASA risk management process is to conduct hazard analyses and quantitative risk assessments to identify and resolve safety threats to NASA flight programs and facilities. OSMQ also performs trend analyses using mission performance and problem data to identify/predict areas that require preventive measures, or corrective actions to assure reliable and maintainable spacecraft. NASA operational safety considerations also include crew safety, range safety, mishap investigations, and implementation of federal safety requirements.

OSMQ's Program Assurance organization serves as the primary interface between OSMQ and NASA Headquarters program offices. Key functions are to establish program-level SRM&QA requirements to address the unique mission, design, and operational characteristics of each program and to ensure compliance with Agency SRM&QA policies. The program assurance organization maintains rigorous oversight of large-scale, complex operations such as the Space Shuttle program and the Space Station program.

In the Technical Standards area, OSMQ develops and maintains engineering standards and capabilities required to enhance the safety, reliability, and performance of NASA missions. OSMQ supports the establishment of NASA-wide standards and practices for design, manufacture, and test of flight systems. Support is also provided for development and demonstration of applied technologies. Key areas of emphasis include aerospace batteries, spacecraft wiring, and pyrotechnic devices. Results from these program activities support the development of future space projects and will lead to improvements in overall mission capability. Planning and managing NASA's transition to the metric system is also supported.

In recognition of the Agency's increasingly complex software requirements, the comprehensive OSMQ software assurance program addresses mission-essential software systems. The office assures that methods, processes, and tools to evaluate software quality are maintained current with the demands of advanced systems. OSMQ evaluates and improves NASA's software engineering processes and products through development of standards and measures and through promotion of technology transfer. OSMQ strives to fully integrate software engineering and assurance into the systems development and operations process.

OSMQ supports NASA programs in the area of Quality Assurance. These efforts include development of standards for parts quality and product assurance, materials treatments and processes, microcircuit radiation effects evaluations, and nondestructive evaluation techniques.

Under its Quality Assurance responsibilities, OSMQ also has supported information gathering and qualification for electrical, electronic, and electromechanical (EEE) spacecraft parts and electronic packaging techniques and a certification program for mechanical parts.

CHANGES FROM FY 1993 BUDGET ESTIMATE

A reduction of $1.0 million has been applied in FY 1993 to the SRM&QA program in response to the Congressionally-directed general reduction of $2.0 million to SRM&QA and Academic programs. This led to reduction of the test and qualification program for radiation-hardened parts to be used in NASA spacecraft.

This reduction is offset by a $1.2 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, OSMQ will continue its initiatives to provide support to the Agency in SRM&QA oversight and direction, and continue to monitor the performance of NASA flight programs. Initiatives to improve NASA use of system engineering, software IV&V, risk methods, and assurance standards and practices will continue.

OSMQ will initiate management of the new NASA IV&V Center in Fairmont, West Virginia, upon its completion in FY 1994. This office will provide overall direction and operations management of the center, including support for research and development of software IV&V techniques and standards.

Another initiative of OSMQ is to conduct a pilot program to enhance the office's direct support of NASA development programs. This initiative is intended to refine methods and techniques for early OSMQ involvement in flight program design and trade-off analysis.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Educational affairs....................	29,800	33,700	56,800	36,800	RD 12-1
Space grant college and fellowship.....	15,000	15,000	13,400	14,500	RD 12-12
Minority university research...........	22,000	22,700	22,700	23,200	RD 13-1
Total..........................	66,800	71,400	92,900	74,500	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

EDUCATIONAL AFFAIRS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Graduate student researchers	7,000	8,200	7,000	7,600	RD 12-3
Summer faculty fellowship	4,000	4,000	3,900	4,100	RD 12-4
Innovative research	2,900	3,100	2,900	3,000	RD 12-5
Mission to planet earth/JOVE	2,800	2,800	2,600	2,700	RD 12-6
Aerospace education services (ASEP)	6,100	7,000	6,500	6,900	RD 12-7
Innovative education	5,500	7,600	5,300	6,000	RD 12-8
Educational technology	1,500	1,000	4,200	1,500	RD 12-9
Special projects	--	--	19,400	--	RD 12-10
EPSCoR	--	--	5,000	5,000	RD 12-11
Total	29,800	33,700	56,800	36,800	

Distribution of Program Amount by Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Johnson Space Center	1,247	1,277	1,355	1,200
Kennedy Space Center	1,126	1,156	1,270	1,100
Marshall Space Flight Center	1,387	1,480	1,525	1,310
Stennis Space Center	920	1,150	1,253	940
Goddard Space Flight Center	1,210	1,240	1,280	1,230
Jet Propulsion Laboratory	1,146	1,176	1,250	1,120
Ames Research Center	1,280	1,310	1,365	1,287
Langley Research Center	1,334	1,390	1,397	1,290
Lewis Research Center	1,350	1,445	1,505	1,305
Headquarters	18,800	22,076	44,600	26,018
Total	29,800	33,700	56,800	36,800

OBJECTIVES AND JUSTIFICATION

The goal of NASA's Education program is to promote excellence in America's education system through enhancing and expanding scientific and technological competence. This program directly supports three of the National Goals for Education, including goal number four that states by the year 2000, U.S. students will be the first in the world in science and mathematics achievement. NASA's program is designed to capture and channel student interest in science, engineering, mathematics, and technology, as well as enhance teacher and faculty knowledge and skills related to these subjects. These Agencywide pre-college, university and minority university programs are in support of NASA's education mission to ensure a sufficient talent pool to preserve NASA and U.S. leadership in aeronautics, space and Earth science, and technology and to help meet the National Education Goals.

The specific objectives of the Educational Affairs program are:

- To communicate to the pre-college educational community -- students, teachers, and administrators -- a better understanding of the knowledge derived from NASA research and development and its application to the study of mathematics, science, and technology;

- To encourage elementary level students to take greater interest in mathematics, science, and technology through the use of advanced instructional technology, development of strong teacher resource centers, curriculum materials designed for the elementary level, and the initiation of cooperative relationships with private industry, local school systems, and community organizations;

- To significantly increase the number of highly trained scientists and engineers in aeronautics, space science, space applications, and space technology to meet the continuing needs of the national aerospace effort;

- To facilitate the direct interaction, further the professional knowledge and stimulate the exchange of ideas between university faculty members and NASA scientists and engineers;

- To support innovative research at U.S. institutions of higher learning that is in the formative or embryonic stage and that would appear to have significant potential to advance space science and applications programs;

- To provide for the development and use of a core, long-term U.S. national university capability to conduct multiyear, Earth science discipline-oriented applied research and remote sensing; and

- To explore the application of state-of-the-art technologies to enhance teaching methods and improve dissemination of education program materials.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The net increase of $23.1 million in FY 1993 includes an increase of $22.2 million for special projects, specifically directed by Congress, an increase of $5 million to initiate the NASA Experimental Program to Stimulate Competitive Research (EPSCoR) consistent with Congressional direction contained in the FY 1993 NASA Authorization Act (P.L. 102-588), offset by a reduction of $1 million as part of a general reduction to Safety, Reliability and Quality Assurance/Education programs directed by Congress, and a further reduction of $3.1 million to offset the increases specified above.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Graduate student researchers..........	7,000	8,200	7,000	7,600

OBJECTIVES AND STATUS

The Graduate Student Researchers program, initiated in 1980, provides graduate fellowships nationwide to post-baccalaureate U.S. citizens to conduct thesis research at a NASA Center or to carry out a program of study or research at their home institution. Awards are made to graduate students for a maximum of three years. On an annual basis, NASA supports approximately 500 graduate students pursuing the masters or doctorate degrees in science, engineering, mathematics, and technology.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding is reduced to partially offset the mandated appropriation requirements from Congress. This will result in maintaining the number of new fellowships awarded in FY 1993 at the FY 1992 level.

BASIS OF FY 1994 ESTIMATE

The FY 1994 request will support additional fellowships at the graduate level, increasing the number of annual awards available yearly at each NASA Center.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Summer faculty fellowships............	4,000	4,000	3,900	4,100

OBJECTIVES AND STATUS

The NASA Summer Faculty Fellowship program has completed 29 years of operation. This program provides highly beneficial opportunities for engineering and science faculty throughout the United States to participate in NASA research. This program has contributed significantly to the improvement of both undergraduate and graduate education, and directly benefited NASA, universities, faculty, students, and the Nation.

The Summer Faculty Fellowship program enables university faculty to spend ten weeks working directly with scientists and engineers at NASA Centers on problems of mutual interest. Participants must have a minimum of two years teaching experience and must be citizens of the United States. The program is designed to further the professional knowledge of faculty members, to stimulate an exchange of ideas between participants and NASA, and to enrich the research and teaching activities of the participants' home institutions. This activity is operated cooperatively with the American Society for Engineering Education (ASEE).

Approximately 300 university faculty are supported annually for ten weeks. Evaluations conducted by ASEE of the program indicate that approximately 30-40 percent of the participating faculty subsequently receive NASA research grants or contracts.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding is reduced to partially offset mandated appropriation requirements from Congress, and will reduce the number of new faculty fellowships awarded in FY 1993.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding level supports the award of increased new faculty fellowships.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Innovative research....................	2,900	3,100	2,900	3,000

OBJECTIVES AND STATUS

A key to the future health and well-being of the Planetary Science and Astrophysics and Mission to Planet Earth programs lies in having the capacity to explore new ideas or novel technical approaches to research. The Innovative Research program is managed through the Offices of Space Science and Mission to Planet Earth to support research which, while still in its formative stage, has already demonstrated potential for significant advances for Planetary Science and Astrophysics and Mission to Planet Earth programs. The program is intended to provide a mechanism for the funding of scientifically sound proposals which might not be funded through normal channels either because of their interdisciplinary nature or because they are speculative or risky. The long-term goal is to help the new ideas mature to a state of acceptability within particular science discipline resources.

Announcements of the availability of funds and NASA's interest in receiving proposals for this type of research have been issued in 1980, 1982, 1985, 1988, and 1991. Emphasis in the program is on the support of innovative research at universities and colleges where involvement of students and new Ph.D. scientists can be enhanced. The program also emphasizes support to new researchers who have only recently completed graduate training. The primary criterion for inclusion in the program has been originality and the promise for innovation of the work being proposed. Over the past several years, a number of major technical advances have resulted from research supported by this program, such as the development of new infrared detector technology using nonstandard scientific approaches, the evolution of RNA enzymes in the laboratory, design of a magnetospheric imager proposed for the Cassini Saturn orbiter, a high pressure Xenon drift chamber for gamma-ray astronomy, varied line space extreme ultraviolet and x-ray gratings, and micro channel plate detectors.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The reduction of $200 thousand is required to offset the mandated appropriation requirements from Congress, and will defer award of some planned new research activities.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will provide for continuation of support for 24 projects selected in 1991 and a reduced number of new awards to be initiated.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission to planet earth/JOVE...........	2,800	2,800	2,600	2,700

OBJECTIVES AND STATUS

In FY 1994, the Joint Venture (JOVE) program will be combined with research activities funded under the Mission to Planet Earth program. The JOVE program supports research and education activities at universities not traditionally involved in NASA's research activities. Fifty-five academic institutions in 37 states and Puerto Rico are currently participating. The Mission to Planet Earth program established a geographically distributed network of universities responsible for conducting research and development in remote sensing data applications, Earth sciences and Earth resources management. By combining these two efforts, NASA will provide research data to a broader range of academic institutions in exchange for faculty and student research time, and will establish and maintain multidisciplinary academic research and training programs for space and Earth sciences. Funding for Mission to Planet Earth research will be transitioned to support the expanded JOVE program over the next three years.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The reduction of $200 thousand is required to offset the mandated appropriation requirements from Congress. The FY 1993 reduction will result in deferral of some activities in the transition between Mission to Planet Earth and JOVE as well as the planned addition of participating institutions under JOVE.

BASIS OF FY 1994 ESTIMATE

In FY 1994, research activities funded under the JOVE and Mission to Planet Earth programs will continue NASA research data available to a broad range of academic institutions, and focus on working with the university community to prepare for the availability of space-based remote-sensing data from the U.S. Global Change program. Faculty at institutions with limited prior involvement in NASA research are encouraged to become members of research teams at NASA Field Centers and established mentor institutions. The JOVE program also promotes educational outreach and provides for the dissemination of space science information at various education levels.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aerospace education services (AESP)....	6,100	7,000	6,500	6,900

OBJECTIVES AND STATUS

The Aerospace Education Services Program (AESP), also known as Spacemobile, is NASA's premier outreach program. The AESP specialists, all former science, math, or technology teachers, capture the interest of millions of students and enhance the teaching skills of teachers each year by using aeronautics and space as a catalyst in the teaching of science, mathematics, and technology. From September to June, AESP specialists visit schools throughout the United States, conducting student assemblies and teacher workshops. During the summer, AESP specialists conduct teacher workshops at the NASA Centers and various colleges and universities.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The reduction of $500 thousand is required to offset the mandated appropriation requirements from Congress. The FY 1993 reduction will eliminate some education outreach programs from the field centers to their respective regions, as well as curtail aerospace specialists school visits throughout the United States to provide teacher in service and conduct student assemblies.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will allow for continuation of the current program, with increased funding targeted toward adding additional specialists and upgrading aerospace models and vans. Activities for FY 1994 include development of instruction media, program evaluation activities, and expansion of the Urban Community Education program to reach additional inner city communities.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Innovative education..................	5,500	7,600	5,300	6,000

OBJECTIVES AND STATUS

The Innovative Education program includes a series of programs targeted at both pre-college teachers and students. The goal is to enhance and improve the teaching of science, mathematics, and technology at the elementary and secondary level by using aeronautics and space as a theme and motivational factor. Programs included are: NASA Education Workshops for Math and Science Teachers (NEWMAST), NASA Education Workshops for Elementary School Teachers (NEWEST), the Space Science Student Involvement Program (SSIP), Summer High School Apprentice Program (SHARP), and community colleges. Program responsibility for the Teacher Resource Center Network (TRCN) has been transferred to Educational Technology.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The reduction of $2.3 million reflects the transfer of $500 thousand for the Teacher Resource Center Network (TRCN) consistent with program management responsibilities, and an additional reduction of $1.8 million to partially offset the mandated appropriation requirements from Congress. As a result of the reduction, the planned expansion of the Summer High School Apprenticeship Program (SHARP) Plus Program and the community college program developed in response to congressional direction will be implemented at a reduced rate. In addition, the number of teachers participating in the Teacher Workshops for Elementary School Teachers/NASA Education Workshops for Math and Science Teachers (NEWEST/NEWMAST) will be reduced. New initiatives planned to expand NASA's education outreach efforts will be deferred.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will allow or the continuation of NASA-sponsored teacher workshops (NEWEST/NEWMAST), and student involvement programs (SHARP, SSIP). Development and implementation of various programs with community colleges to ensure the continuation of quality technicians for the aerospace effort, and for development of curriculum materials which relate to NASA missions that can be used in the classroom will also be continued.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Educational technology................	1,500	1,000	4,200	1,500

OBJECTIVES AND STATUS

NASA's Education Technology effort is an essential component of the Agency's Education program. Educational technology products and services produced will ensure that NASA is able to develop the same level of leadership in technology education as it has in aeronautics and space technology. Additionally, the 21st Century Classroom, a component of the Classroom of the Future, will serve as a research and evaluation center where students and their teachers can utilize advanced educational technologies. Educational technology comprises the major element of the NASA dissemination plan.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase in FY 1993 reflects the transfer of $500 thousand for the Teacher Resource Center consistent with program management responsibilities, the addition of $2.8 million for Classroom of the Future as directed by Congress, and a reduction of $100 thousand to partially offset the mandated appropriations requirements by Congress.

BASIS FOR FY 1994 ESTIMATE

The FY 1994 funding will allow for the development of several technology-based products of high priority to the Education Division. These include a videodisk for Earth systems science, a feasibility study of a telecourse for teachers, and enhancements to the Spacelink Computer Information system. Funding will be used for NASA Select educational video programming, expansion of the Regional Teacher Resource Center Network, hands-on participatory science using computers and telecommunication systems, and the Classroom of the Future.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Special projects......................	--	--	19,400	--

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase in FY 1993 represents funding for specific projects directed by Congress in the Conference Report (House Report 102-902) accompanying the VA-HUD-Independent Agencies Appropriations Act (P.L. 102-389). These projects are:

Nebraska Department of Education	-	Expand NASA Teacher Resource Room ($0.4 million)
Oregon Systems of Higher Education	-	Computer Network Infrastructure ($4.5 million)
Oregon State University	-	Marine Science Center ($0.5 million)
Kansas Cosmosphere	-	Informal science activity at planetarium ($4 million)
University of Utah	-	Intermountain Network and Scientific Computation Center ($10 million)

In addition, $2.8 million is included in Educational Technology for Classroom of the Future, consistent with direction contained in House Report 102-902.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
EPSCoR................................	--	--	5,000	5,000

OBJECTIVES AND STATUS

Title III of the FY 1993 NASA Authorization Law (P.L. 102-588) directs NASA to establish a "competitive program to strengthen the competitive research capacity in those geographic areas of the NASA which are not currently fully competitive". This program, modeled after the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR), will use the existing EPSCoR network to allow these states, which are not strong competitors for research funds, to strengthen their ability to compete for research grants in areas of research important to the mission of NASA. This program will be closely coordinated with the Space Grant College and Fellowship program. Many of the Space Grant College program Phase II consortia are also EPSCoR states.

CHANGES FROM FY 1993 ESTIMATE

NASA has reallocated $5 million to initiate this program. In FY 1993, efforts will focus on the design of the program, as well as make first grants.

BASIS FOR FY 1994 ESTIMATE

The FY 1994 funding will continue implementation of NASA's Experimental Program to Stimulate Competitive Research on Space and Aeronautics by renewing the grants made in FY 1993. These grants facilitate the building of research capability and improve the education environment of states that are not currently competitive for the research and education activities of NASA.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS — **NATIONAL SPACE GRANT COLLEGE AND FELLOWSHIPS**

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Space grant college and fellowships....	15,000	15,000	13,400	14,500
Distribution of Program Amount by Installation				
Headquarters........................	15,000	15,000	13,400	14,500
Total...........................	15,000	15,000	13,400	14,500

OBJECTIVES AND STATUS

The Space Grant College and Fellowship program is composed of three principal and interrelated elements: Designated Space Grant Colleges/Consortia, Space Grant Program Consortia, and Space Grant Capability Enhancement Consortia. Designated Space Grant Colleges/Consortia, of which 21 were selected in 1989 are preeminent institutions which are substantially involved in a broad spectrum of NASA research, offer advanced study in aerospace fields, and are significantly involved in related public service. Designated Colleges/Consortia each received $75,000 in start-up funds in FY 1989 and from $250,000-$325,000 in FY 1990 and 1991, depending on consortium affiliations. In FY 1992 and 1993 Designated schools received from $295,000-$380,000, which includes $20,000 augmentation to all schools, and a chance to receive additional funding of $35,000 depending upon the size of the consortium. In FY 1991, a new competition took place: consortia within states not represented by Designated Colleges/Consortia were invited to apply either for Program Grants or for Capability Enhancement Grants (the difference between the two types of programs related to current involvement in aerospace fields). Twenty-nine proposals were received. Of those 29, 14 were funded as Program Grants, 12 as Capability Enhancement Grants and three as planning grants. Selections were announced in February 1991. Program Grant and Capability Grant awardees received $150,000 in FY 1991.

a portion of which was to be used for fellowships. In FY 1992, the states received an additional augmentation of $20,000, with a chance to receive an additional $35,000, depending upon the size of the consortium. The three states, which received planning grants of $25,000 each were brought into the program as fully-funded proposals, along with Vermont and Puerto Rico, in FY 1992.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The $1.6 million reduction is required to partially offset the mandated appropriation from Congress. The reduced funding level requires that continuing and new initiatives, such as new designation status for Program Grant consortia, funding for unsolicited proposals, and the proposed Space Grant Centers for Excellence in Undergraduate Training, will have to be deferred.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will continue implementation of the National Space Grant College and Fellowship program by funding the original 21 consortia and to fully fund 31 Phase II grantees. Funds will also be used to perform critical program evaluation which includes site visits to Space Grant College campuses and to convene the legislatively-mandated Space Grant Review Panel.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Historically black colleges and universities	11,000	11,400	11,400	12,200	RD 13-4
Other minority universities	4,700	4,800	4,800	4,532	RD 13-6
Graduate student researchers program (underrepresented minority focus)	3,300	3,400	3,400	3,368	RD 13-7
Undergraduate student researchers program (Underrepresented minority focus)	3,000	3,100	3,100	3,100	RD 13-8
Total	22,000	22,700	22,700	23,200	
Distribution of Program Amount by Installation					
Johnson Space Center	2,543	941	1,559	1,474	
Kennedy Space Center	--	260	--	--	
Marshall Space Flight Center	450	814	980	922	
Stennis Space Center	70	340	100	100	
Goddard Space Flight Center	544	850	746	722	
Jet Propulsion Laboratory	--	700	900	900	
Ames Research Center	20	512	157	150	
Langley Research Center	2,286	1,186	1,203	1,024	
Lewis Research Center	495	716	366	362	
Headquarters	15,592	16,381	16,689	17,546	
Total	22,000	22,700	22,700	23,200	

ACADEMIC PROGRAMS

MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM

OBJECTIVES AND JUSTIFICATION

One of the national goals in science and education is to expand the number of women and minority graduate and undergraduate students receiving degrees in math, science, and engineering. NASA is committed to expanding opportunities for talented students from underrepresented groups pursuing degrees in engineering and science disciplines. The goal of the NASA Minority University Research and Education programs is to expand the pool of talented students to include more women and members of underrepresented minority groups, through a strong alliance between Historically Black Colleges and Universities, Other Minority Universities, majority research institutions, elementary and secondary schools, industry and other Federal R&D agencies. Funding to Historically Black Colleges and Universities and other Minority Universities supports the strengthening of the research capabilities and infrastructure of these institutions, to make them competitive for mainstream NASA research funding. NASA provides support through research opportunities and fellowships underrepresented graduate and undergraduate students who are pursuing degrees in science and engineering fields. An additional responsibility for NASA and the Minority University Research and Education Division (MURED) will be to strengthen relationships with teacher training and enhancement activities in collaboration with minority universities and school systems. This effort will ensure that opportunities for K-12 teachers and students at elementary and secondary schools with significant minority enrollments are enhanced under Executive Order 12821, entitled "Improving Mathematics and Science Education in Support of the National Educational Goals."

NASA's Historically Black Colleges and Universities initiative is mandated by Executive Order 12677, which requires Federal agencies to increase significantly the involvement of Historically Black Colleges and Universities in Federally sponsored programs. Congress also directed NASA in FY 1985, to build closer relationships with universities that tend not to be major research institutions, but do have significant minority enrollments. To accomplish this goal, the Agency has established the Other Minority Universities (OMU) program to focus on meeting NASA's research objectives, and concurrently, increase the number of individuals from underrepresented groups in the pool of graduate researchers while not diminishing the Agency's effort toward Historically Black Colleges and Universities. Additionally, under the auspices of the Other Minority Universities program, NASA is responsive to Executive Order 12729 on Educational Excellence for Hispanic Americans, which directs Federal agencies to be actively involved in helping advance educational opportunities for Hispanic Americans.

NASA implements both the Historically Black Colleges and Universities and Other Minority Universities programs' initiatives primarily using research and training grants sponsored through the MURED in the Office of Equal Opportunity programs (OEOP). The research and training grants focus on specific research disciplines relevant to NASA requirements in science and technology and are used to support faculty and students at Historically Black Colleges and Universities and Other Minority Universities, thereby increasing the scientific and technological contributions from these institutions and increasing the pool of minorities in NASA-related science and engineering disciplines. In FY 1992, the NASA Program Offices (POs) became more directly involved and responsible for the selection, funding and conduct of minority university research. The Program Offices are working collaboratively with the OEOP to expand institutional research capability at minority universities and to enhance research opportunities for faculty principal investigators (PIs) and student researchers in the Program Offices areas of responsibilities. Ultimately, it is anticipated that the institutions, faculty, and students will compete successfully in NASA's mainstream research and employment processes. This new process also facilitates NASA's efforts to comply with the Congressional direction that 8 percent of NASA's total procurements shall go to small, minority, and women-owned businesses including Historically Black Colleges and Universities and Minority Universities.

To encourage the development of talent at the undergraduate and graduate level, NASA will continue the Graduate Student Researchers program/underrepresented minority focus and the Undergraduate Student Researchers program/underrepresented minority focus. The Undergraduate Student Researchers program/underrepresented minority focus was introduced in FY 1991, based on the recommendations of NASA PIs. The concept also is in consonance with the recommendations of the National Task Force on Women, Minorities, and the Handicapped in Science and Technology, which urged the establishment of a variety of scholarships, fellowships, hands-on research experience and other support to capture and develop these groups. It has become increasingly apparent that many promising minority high school graduates with excellent grade point averages and SAT scores enter college, but do not elect science and engineering fields. Further, many of the minority science and engineering students who succeed at the undergraduate level and who have the ability to do graduate level research, never consider research as a career option. Through the Undergraduate student researchers program/underrepresented minority focus, NASA PIs involve minority students pursuing masters and Ph.D. degrees in areas of interest to NASA in NASA-sponsored research projects. The objective of both these programs is to build a pipeline of talented underrepresented minority students to ensure increased numbers for graduate studies.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Historically black colleges and universities (HBCU).................	11,000	11,400	11,400	12,200

OBJECTIVES AND STATUS

The objectives of the Historically Black Colleges and Universities program are to continue to increase the level of NASA's participation with Historically Black Colleges and Universities and to strengthen the infrastructure of selected universities. Special emphasis will be placed on enhancing the math and science abilities of students at these universities, which will lead to careers in science and engineering research. Demographic changes forecast for the United States make it mandatory for NASA to increase the science and engineering pipeline of students available in order to sustain technical workforce requirements through the 21st century.

During FY 1991, seven Historically Black Colleges and Universities Research Centers were competitively selected in science and technology disciplines related to NASA research requirements. These Historically Black Colleges and Universities Research Centers received initial funding in FY 1992 and have begun regular meetings with the NASA Field Installations and Headquarters program offices to implement focused research activities leading to "mainstream" capability at the Historically Black Colleges and Universities. Research center activities include PIs, undergraduate students and graduate students. Collaborative efforts between the Minority University Research and Education Programs Division and the NASA technical offices will provide long-term guidance for the Historically Black Colleges and Universities Research Centers with funding and technical oversight. In FY 1994, the Historically Black Colleges and Universities Research Centers will be primarily funded by the Office of Space Flight (OSF), the Office of Space Science (OSS), Office of Mission to Planet Earth (OMTPE), and the Office of Aeronautics (OA).

Funding for individual unsolicited PI proposals will continue and grants will be awarded for research and for training to bring new talented faculty members into the research arena on a regular basis. New science and engineering grants will provide for a broader range of space science and technology efforts at Historically Black Colleges and Universities, with emphasis on nurturing new technologies for OSS, OMTPE, OA and other NASA technical offices.

All ongoing and new Historically Black Colleges and Universities research activities will be funded by the program offices referenced above and the Office of Minority University Research. This continued collaboration will accelerate the developmental process at the Historically Black Colleges and Universities institutions and facilitate their contributions to NASA's research efforts.

BASIS OF FY 1994 ESTIMATE

Funding will be used to support the seven Historically Black Colleges and Universities Research Centers, provide support for individual Principal Investigator grants, and to continue award of training grants. Funding from the program offices will complement funds from OEOP to continue Historically Black Colleges and Universities research efforts.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Other minority universities (OMU)......	4,700	4,800	4,800	4,532

OBJECTIVES AND STATUS

The objectives of the Other Minority Universities program are to continue to work in collaboration with NASA Program Offices and Field Installations to implement a comprehensive program that provides opportunities for universities with significant minority enrollments to compete for individual PI awards, institutional research awards, and educational and training awards. These awards will enhance the retention and advancement of minority and disabled secondary students in mathematics-based curricula, expand science and math enrichment opportunities for in-service teachers, and increase cultural diversity among pre-service mathematics and science teachers at schools with significant minority enrollments.

In FY 1993, the Office of Space Science and the Office of Aeronautics (OA) continue to provide the majority of funding for NASA research conducted at Other Minority Universities s while OEOP funds all the educational and training programs at these institutions. Additionally, OSS and the OA worked with OEOP to implement and jointly fund a new research program entitled the Faculty Awards for Research (FAR) Underrepresented Minority Focus program in FY 1992. The goal of the FAR program is to achieve NASA's mission while enhancing cultural diversity in the NASA-sponsored research community. Since implementing the FAR program, twenty-four outstanding and promising faculty researchers have been competitively selected to conduct research in NASA-related fields of space and Earth sciences, and aerospace technology. Each FAR recipient has been assigned a technical monitor at a NASA Installation or at the Jet Propulsion Laboratory. Each FAR award provides support of the planned research activities for up to three years based on the annual determination of continuing achievement and subject to the availability of funds.

BASIS OF FY 1994 ESTIMATE

In FY 1994, NASA will continue to fund comprehensive educational and training programs at Other Minority Universities s and will jointly fund with NASA Program Offices, research conducted at universities with significant minority enrollments including the FAR and Institutional Research Awards for Minority Universities (IRAMUs). It is expected that ten additional FAR and several IRAMUs will be made during this period. It is anticipated that the IRAMUs will be awarded for a five year period starting with a funding level of $200,000 per year, increasing up to an annual funding level of $500,000. These awards will provide for research and supporting equipment and faculty development in areas relevant to NASA's mission. Additionally, OEOP will competitively select Other Minority Universities to receive Math and Science Awards for Teacher and Curriculum Enhancement programs (MSATCE). It is expected that awards for the MSATCE program will be for four years with a maximum funding level of $150,000 annually.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Graduate student researchers program (underrepresented minority focus) (GSRP/UMF)	3,300	3,400	3,400	3,368

OBJECTIVES AND STATUS

The objectives of the Graduate Student Researchers program/underrepresented minority focus programs are to enhance the development of underrepresented minority talent in an effective way so as to utilize the potential of this Nation's diverse citizenry; and to increase the size of the resource pool of research skills that will be needed to meet aerospace and other technological objectives of the future. Principal investigators who have NASA research grants and a need for further student involvement will be encouraged to seek out talented underrepresented minority students and involve them in their NASA research projects. The underrepresented minorities who are the special focus of this program include African-Americans, Hispanics, American Indians and Pacific Islanders. They must be enrolled in masters or doctoral programs in engineering, physics, mathematics, computer science, biology, or other disciplines of interest to NASA. Data show that approximately 60 percent of the Graduate Student Researchers program/underrepresented minority focus students are in Ph.D. programs, and that African-Americans and Hispanics make up about 90 percent of the program population. This is particularly encouraging since recent national scientific manpower data show African-Americans and Hispanics making the least educational advancement of all target groups in science and engineering.

In FY 1992, the sixth year of the program, an additional 53 underrepresented minority students were selected for a total of 118 participants in the program. This total included 38 African-Americans males, 12 African-Americans females, 50 Hispanic males, 7 Hispanic females, 3 American Indian males, 1 American Indian female, 3 Pacific Islander males and 3 Pacific Islander females and 1 disabled male. FY 1993 shows a continuing upward trend in applications and candidates.

BASIS OF FY 1994 ESTIMATE

Funding in FY 1994 will support an additional 70 students in this program. This increase is attributable to the tremendous growth in interest and competitiveness within the program.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Undergraduate student researchers program (USRP) (underrepresented minority focus)...	3,000	3,100	3,100	3,100

OBJECTIVES AND STATUS

This program, begun in FY 1991, identifies high ability high school senior and continuing first year underrepresented minority students majoring in science or engineering and awards them portable scholarships through universities with proven records of recruiting, retaining, and graduating minority science and engineering students. This program will grow by approximately 75 students each year, so that by the 4th year NASA expects to be supporting approximately 300 students through the program. Our projected graduation rate is 85-90 percent, based on the fact that to date only 3 percent of the original class has dropped out of the program. The students receive tuition support; are monitored, tutored and nurtured; and spend their summers conducting research with principal investigators at their universities, NASA Installations, federal laboratories or private industry. The pipeline of undergraduate minority students majoring in the physical and life sciences and engineering coming from this program is expected to substantially and positively impact NASA's hiring needs. Even more important, these students are being targeted for graduate level studies and research careers in the fields of science and engineering. The Graduate Student Researchers program/underrepresented minority focus may serve as a feeder to the Undergraduate Student Researchers program/underrepresented minority focus. FY 1993 saw a major growth in the program, as it expanded to 225 students representing scientific and technical disciplines related to NASA's workforce needs projected over the next ten years.

In FY 1992, the second year of the program, an additional 80 underrepresented minority students were selected for a total of 154 participating in the program. This total included 78 African-Americans, 58 Hispanics, 10 Native Americans, 2 Pacific Islanders, and 6 students with disabilities.

BASIS OF FY 1994 ESTIMATE

The funding level of the Undergraduate Student Researchers program/underrepresented minority focus will approximate the funding level of the Graduate Student Researchers program/underrepresented minority focus. Since the undergraduate component will serve as a feeder to the graduate component, the proposed budget structure for the undergraduate component represents a natural progression. NASA's goal is to have a continuous flow of minority undergraduate and graduate level students in science and engineering educational tracks.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS

ADVANCED SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
Advanced systems	22,000	23,200	23,273	24,600
Distribution by Program Amount by Installation				
Goddard Space Flight Center	6,100	6,200	6,373	6,400
Jet Propulsion Laboratory	15,400	16,500	16,400	17,600
Headquarters	500	500	500	600
Total	22,000	23,200	23,273	24,600

OBJECTIVES AND STATUS

The objective of the Advanced System program is to improve the performance, capability and reliability of future space missions in the critical areas of communications, navigation, and mission operations. This is accomplished in the program by evaluating and developing new technologies to demonstrate their feasibility to a level that allows field implementation to be undertaken with confidence. The research and development under this program has, over the years, enabled the cost-effective introduction of new technology and techniques into the Deep Space Network, the Space Network, and Communications and Data Systems. The Advanced Systems program is critical to maintain and improve our capabilities in the future.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase of $0.073 million is the result of transferring funds from the Research Operations Support (ROS) account.

BASIS OF FY 1994 ESTIMATE

Advances in tracking and navigation are essential for highly accurate science and communications missions such as Galileo, Mars Observer, Pluto-Flyby, TOPEX-Poseidon, and the Tracking Data Relay Satellite. Activities in FY 1994 will include research to provide position determination of Earth-orbiting spacecraft into an accuracy of a few centimeters and determinations, from Earth, of the angular direction of interplanetary spacecraft to a few nano-radians.

For communication between spacecraft and the ground, technology will be developed to improve existing radio frequency capabilities and enable new microwave and optical systems for future use. Developments in this area will include transmitters, receivers, multi-frequency feeds and reflectors in the S, X, Ku, and Ka bands of the radio spectrum (2, 8, 12, and 32 GHz). Optical communications systems for future use will be studied, concepts developed, analyzed and compared to microwave systems for cost and performance.

Future missions will have high resolution multi-spectral sensors and payloads operating at very high data rates and data volumes. Data handling technology will be developed to process, store and transmit at the high rates and volumes required by such missions. Another part of the effort is concerned with technology to increase the capability and efficiency of mission operations. This involves the increased use of automation, and development and application of knowledge-based techniques; including expert systems, artificial intelligence and improved graphics for easier human-machine interaction. Commercial open system standards will be emphasized to minimize development and cost.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

GENERAL STATEMENT

The objective of the National Aeronautics and Space Administration program of Space Flight, Control and Data Communications is to provide for the operational activities of the space transportation system and the tracking and communication system support to all NASA flight projects. This objective is achieved through the following elements:

SHUTTLE PRODUCTION AND OPERATION CAPABILITY: A program to provide a fully capable fleet of Space Shuttle orbiters, main engines, launch site and mission operations control requirements, spares inventory, production tooling, and other investments needed to maintain the long-term viability of the Shuttle program.

SHUTTLE OPERATIONS: A program to provide the standard operational support services for the Space Shuttle. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and manpower, propellants, and other materials are furnished to conduct both flight and ground (launch and landing) operations.

LAUNCH SERVICES: A program to provide for procurement of expendable launch vehicle services.

SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS: A program to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects using ground-based and satellite (Tracking and Data Relay Satellite System) components.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
	(Thousands of Dollars)			
SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	1,296.4	1,012.8	1,053.0	1,189.6
SHUTTLE OPERATIONS	3,029.3	3,115.2	3,016.0	3,006.5
LAUNCH SERVICES	155.8	217.5	180.8	300.3
SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS	903.3	921.0	836.2	820.5
TOTAL	5,384.8	5,266.5	5,086.0	5,316.9

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

Space Flight, Control and Data Communications

For necessary expenses, not otherwise provided for, in support of space flight, spacecraft control and communications activities of the National Aeronautics and Space Administration, including operations, production, services, minor construction, maintenance, repair, rehabilitation, and modification of real and personal property; tracking and data relay satellite services as authorized by law; purchase, lease, charter, maintenance and operation of mission and administrative aircraft; [$5,086,000,000] *$5,316,900,000*, to remain available until September 30, [1994] *1995*. *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1993.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

REIMBURSABLE SUMMARY
(In thousands of dollars)

	Budget Plan		
	1992	1993	1994
Shuttle production and operational capability	67,043	22,914	16,375
Shuttle operations	110,713	51,464	60,750
Launch services	81,034	90,195	87,300
Space and ground networks, communications and data systems	60,288	91,823	95,000
Total	319,078	256,396	259,425

NATIONAL AERONAUTICS AND SPACE ADMINSTRATION

FISCAL YEAR 1994 ESTIMATES

DISTRUBTION OF SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Goddard Space Flt Center	Jet Propulsion Lab	Ames Research Center	Langley Research Center	Lewis Research Center	NASA HQ
Space Transportation Sys	1992	4,325,700	1,279,900	1,073,000	1,837,100	41,200	0	0	5,900	200	600	87,800
	1993	4,068,969	1,248,100	1,078,800	1,572,800	37,600	0	0	6,700	0	0	124,969
	1994	4,196,100	1,311,500	1,066,900	1,728,400	41,900	0	0	6,300	0	0	41,100
Shuttle Production	1992	1,296,400	413,200	125,900	713,300	28,800	---	---	---	200	600	14,400
	1993	1,053,016	383,600	96,300	507,100	24,100	---	---	---	---	---	41,916
	1994	1,189,600	414,300	88,600	639,600	28,500	---	---	---	---	---	18,600
Shuttle Operations	1992	3,029,300	866,700	947,100	1,123,800	12,400	---	---	5,900	---	---	73,400
	1993	3,015,953	864,500	982,500	1,065,700	13,500	---	---	6,700	---	---	83,053
	1994	3,006,500	897,200	978,300	1,088,800	13,400	---	---	6,300	---	---	22,500
Launch Services	1992	155,800	---	8,000	---	---	83,900	---	---	---	63,900	---
	1993	180,801	---	9,600	47,301	---	77,600	---	---	---	46,300	---
	1994	300,300	---	10,300	51,100	---	93,400	---	---	---	145,500	---
Space & Ground Networks,	1992	903,275	21	700	56,300	---	581,823	177,739	13,000	1	200	73,491
Communciations, & Data	1993	836,230	200	---	58,200	---	532,521	187,400	15,663	---	200	42,046
Systems	1994	820,500	---	---	59,620	---	516,780	185,800	17,700	---	200	40,400
TOTAL BUDGET PLAN	1992	5,384,775	1,279,921	1,081,700	1,893,400	41,200	665,723	177,739	18,900	201	64,700	161,291
	1993	5,086,000	1,248,300	1,088,400	1,678,301	37,600	610,121	187,400	22,363	0	46,500	167,015
	1994	5,316,900	1,311,500	1,077,200	1,839,120	41,900	610,180	185,800	24,000	0	145,700	81,500

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT | **SPACE SHUTTLE PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Shuttle production and operational capability..........................	1,296,400	1,012,800	1,053,016	1,189,600	SF 1-1
Shuttle operations....................	3,029,300	3,115,200	3,015,953	3,006,500	SF 2-1
Total..........................	4,325,700	4,128,000	4,068,969	4,196,100	
Distribution of Program Amount By Installation					
Johnson Space Center..................	1,279,900	1,324,700	1,248,100	1,311,500	
Kennedy Space Center..................	1,073,000	1,056,700	1,078,800	1,066,900	
Marshall Space Flight Center...........	1,837,100	1,573,000	1,572,800	1,728,400	
Stennis Space Center..................	41,200	30,600	37,600	41,900	
Langley Research Center................	200	--	--	--	
Lewis Research Center..................	600	--	--	--	
Ames Research Center..................	5,900	5,800	6,700	6,300	
Headquarters..........................	87,800	137,200	124,969	41,100	
Total..........................	4,325,700	4,128,000	4,068,969	4,196,100	

OFFICE OF SPACE FLIGHT — SPACE SHUTTLE PROGRAM

OBJECTIVES AND JUSTIFICATION

The primary program objective of the Space Shuttle is to continue supporting NASA launch requirements while maintaining the program focus on safety and mission success demonstrated since returning the Shuttle to flight. The Shuttle is a key element of America's space program because of its unique capabilities. The Shuttle is the first reusable space vehicle and is configured to carry many different types of space apparatus, spacecraft and scientific experiments. In addition to transporting materials, equipment and spacecraft to orbit, the Shuttle offers unique capabilities such as: retrieving payloads from orbit for reuse; servicing and repairing satellites in space; safely transporting humans to and from space; operating and returning space laboratories.

The Shuttle program strategic thrust is to maintain the capability to fly eight flights per year. In addition, the program is currently implementing modifications that will improve the safety margins of the Shuttle by a factor of two as well as providing performance and capability enhancements such as a 30-day Extended Duration Orbiter (EDO) capability. However, the program is acutely aware that providing reliable access to space must be cost-effective if we expect to exploit our capability. As a result, major cost reductions have been implemented since the FY 1992 Congressional budget.

The Shuttle is funded under two budget line items: Shuttle Production and Operational Capability and Shuttle Operations. Shuttle Production and Operational Capability provides for continued modification and improvement to the flight elements and ground facilities. This investment is necessary to enhance Shuttle capabilities, sustain the flight rate, and expand safety and operating margins. This line item contains the following major subdivisions: Orbiter Operational Capability, Propulsion Systems, the Advanced Solid Rocket Motor (ASRM), Launch and Mission Support, and Safety and Obsolescence Upgrades, previously designated Assured Shuttle Availability (ASA). The Shuttle Operations budget provides for the launch of NASA missions, as well as missions for certain commercial and international users on a reimbursable basis. Within Shuttle Operations, funding is provided in four areas: flight operations, flight hardware, launch and landing operations, and research operations support. The Shuttle launch schedule calls for a maximum flight rate of eight per year in FY 1993 through FY 1995. The Operations budget is also the major source of efficiencies that have served to significantly reduce the cost of flying the Shuttle. When measured from the FY 1992 President's budget baseline for FY 1993 and FY 1994, over 20 percent reduction will be realized although a small portion is due to changes in the planned flight rate.

The FY 1994 Space Flight budget reflects the study of incorporating Russian space technology into planned NASA activities. At the June 1992 summit meeting in Washington, President Bush and Russian President Yeltsin discussed a series of space initiatives their two countries would pursue based on a Joint Statement of Cooperation in Space signed on June 17, 1992. In July 1992, the NASA Administrator signed a Memorandum of Discussion with the General Director of the Russian Space Agency which outlined a cooperative Human Space Flight program. The program involves flying a Russian cosmonaut aboard a Shuttle flight later this year and an astronaut will fly to the Mir on a Soyuz spacecraft in 1995. Later in 1995, the orbiter Atlantis will dock with the Mir and life science experiments will be conducted. The NASA astronaut and the two cosmonauts who have been on Mir will be returned on the Shuttle to the United States for continued post-flight life science studies. The necessary modifications to the orbiter along with purchase of the Russian docking mechanism is included in this budget. Two other possible areas of technology sharing are the use of the Soyuz-TM spacecraft as an interim rescue vehicle for Space Station and the use of Russian hardware for Automated Rendezvous and Capture (AR&C) to support potential unmanned resupply to the Space Station.

BASIS OF FY 1994 FUNDING REQUIREMENT

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Orbiter operational capability	278,600	305,500	297,016	297,200	SF 1-4
Propulsion systems	357,000	357,700	293,400	297,900	SF 1-7
Advanced solid rocket motor (ASRM)	315,000	--	195,000	280,400	SF 1-10
Launch and mission support	241,200	210,700	178,100	173,900	SF 1-12
Safety and obsolescence upgrade	104,600	138,900	89,500	140,200	SF 1-14
Total	1,296,400	1,012,800	1,053,016	1,189,600	

Distribution of Program Amount by Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Johnson Space Center	413,200	420,200	383,600	414,300
Kennedy Space Center	125,900	110,000	96,300	88,600
Marshall Space Flight Center	713,300	422,100	507,100	639,600
Stennis Space Center	28,800	18,000	24,100	28,500
Langley Research Center	200	--	--	--
Lewis Research Center	600	--	--	--
Headquarters	14,400	42,500	41,916	18,600
Total	1,296,400	1,012,800	1,053,016	1,189,600

OBJECTIVES AND STATUS

Shuttle Production and Operational Capability provides for development activities to improve Shuttle safety margins, ensure the continual availability of existing capabilities, and a limited expansion of Shuttle capabilities when required by specific customer flight requirements. Included in this budget line are: orbiter design modifications and improvements necessary to support the Space Shuttle; continued development and testing of propulsion systems; continuation of the Advanced Solid Rocket Motor (ASRM) development; capabilities at the launch site and mission control center to support the launch and flight operations process; and development of safety improvements as well as replacement of obsolete systems to ensure the long term viability of the Shuttle program.

Orbiter Operational Capability provides for necessary improvements, modification kits, and mission kits that enable the orbiter fleet to satisfy flight requirements. Although the production of additional orbiters is not planned, the production of high-risk spares like aero surfaces and doors will continue. The Extended Duration Orbiter (EDO) development is funded to increase the on-orbit duration from the baseline 7-10 days, enabling the Shuttle to support an increased variety of payload requirements. Two new items are now included in this budget line and they are: (1) support for an FY 1995 docking with the Russian Mir Space Station and, (2) an expansion of the EDO to support missions of up to 30 days.

Propulsion systems funds the production, continued development, and extensive testing of the Space Shuttle Main Engine (SSME) and the development of capability enhancements to support Solid Rocket Booster (SRB) operational requirements. The SSME program is focused on improving operating margins by introducing safety, life extension, and producibility enhancements. Funding in this line pays for spare hardware, personnel, and other support needed to develop and test these enhancements. The SSME production program also buys new, replacement engines to support the flight and ground test program. The SRB production and capability development activities include static test firing of redesigned solid rocket motors to certify new subsystem developments for flight, to obtain engineering data on motor performance, and to reclaim reusable hardware needed for the flight program. Development of an asbestos-free insulation for the solid rocket motor is also included. Propulsion activities also cover modifications to booster hardware and ground support equipment.

The ASRM project is designed to improve flight safety, reliability, producibility, and performance of the Space Shuttle's Solid Rocket Motor through new design, materials and manufacturing processes. Flight safety and reliability will be improved by reducing failure modes. Producibility will be enhanced through new, highly automated facilities that will use the most efficient production tools in the solid rocket motor industry. The ASRM increase in Shuttle payload lift capability of 12,000 pounds will be achieved through a more energetic propellant, improved design configuration, and reduced inert weight. The impact to other Space Shuttle elements will be limited without compromise to flight safety and reliability. The ASRM program has recently undergone a restructure in response to the FY 1993 appropriated funding levels and the FY 1994 budget request and is now scheduled to support a first flight at the end of calendar year 2000.

Launch and Mission Support funds investment in ground facilities at both the launch site and mission control so that the planned flight rate can be safely maintained. At the Kennedy Space Center (KSC), these investments are required to replace obsolete systems or to improve process efficiency. At the Johnson Space Center (JSC), mission support provides for improvements in the flight support systems such as Shuttle training and carrier aircraft, the Mission Control Center (MCC), the Shuttle Mission Simulator (SMS), and the Flight Analysis and Design System (FADS).

Previously titled Assured Shuttle Availability (ASA), the Safety and Obsolescence Upgrade program provides improvements to the flight hardware and ground systems required to maintain the long-term viability of the Shuttle program. This change reflects a new, major objective in the Shuttle program to dramatically improve safety margins. Desired safety improvements in support of this objective will be designed, developed and implemented in this budget. In the past, these types of activities would have become reliability concerns and would have been funded by individual projects as requirements evolved. An aggressive program to replace obsolete flight hardware and ground systems is mandatory as the Shuttle ages if we are to realize the full investment in the program. To ensure that the highest priority requirements for the program are supported in a timely and cost-effective manner, individual projects are funded based on a program-wide vulnerability assessment.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Overall, Shuttle Production has increased $40.2 million in FY 1993. This is the result of the addition of the ASRM by Congress in FY 1993 at a funding level of $195 million. Partially offsetting this increase are decreases in orbiter operational capability, propulsion systems, launch and mission support, and safety and obsolescence upgrades. To accommodate a general reduction directed by Congress in FY 1993, allowances for potential changes were constrained to an absolute minimum in orbiter and propulsion systems. Other decreases include: (1) reduced testing on the main engines, (2) reductions in the structural spares program, (3) reassessments of equipment upgrades at KSC and JSC, and (4) reductions in the safety and obsolescence upgrades due to the deferral of implementation of the LOX pump as well as reducing new studies and candidates.

BASIS OF FY 1994 FUNDING REQUIREMENT

ORBITER OPERATIONAL CAPABILITY

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Orbiter	158,800	196,900	179,516	127,100
Mir support	30,500	--	37,500	53,000
Extended duration orbiter (EDO)	10,700	21,700	22,600	67,700
Structural spares	57,600	51,000	35,000	35,000
Systems integration	7,200	26,900	13,400	14,400
Orbiter spares	13,800	9,000	9,000	--
Total	278,600	305,500	297,016	297,200

OBJECTIVES AND STATUS

Orbiter production activities include safety modifications, capability improvements, and the development and installation of necessary hardware, software, and procedural modifications for the orbiters, the Remote Manipulator System (RMS), and the Extra-Vehicular Activity (EVA) capabilities. Work continues on improvements to achieve greater operational capabilities, reduce operational costs, and meet system requirements. In addition, there are system level engineering analysis tasks to expand safety margins and performance capabilities.

Funding is provided for Atlantis (OV-104) to dock with the Russian Mir Space Station in June 1995. The objectives of this mission are to: (1) demonstrate the docking concept with the Shuttle before potential use on the Space Station, (2) examine the potential use of the Russian docking mechanism for Station, (3) enhance our understanding of long duration operations, and (4) obtain life science benefits from long-duration research. To achieve these objectives, the flight will be a Spacelab long module mission with life science experiments. In addition, this mission will deliver two Russian cosmonauts and return to Earth three Mir crew members who will be subjected to extensive post-flight research while they recover from the mission. Funding for the Spacelab portion of this mission is included under the Spacelab budget, while the science costs are part of the Space Science budget. Funding under this budget line purchases the Russian docking mechanism through a Rockwell contract with NPO Energia. The costs for Rockwell to modify the mechanism and to integrate it with the orbiter are also included.

The Extended Duration Orbiter (EDO) program provides for the necessary capabilities to extend the on-orbit duration from the baseline of 7-10 days. The first phase provides a cryogenic pallet system to support Spacelab-type flights for periods up to 16 days. The initial pallet development was financed by Rockwell, and funding is provided as part of the commercialization agreement. Logistics items affected by extended on-orbit operations such as repair parts for fuel cells are also included. Columbia is the initial EDO vehicle and the first flight utilizing the pallet was in June 1992 on the United States Microgravity Laboratory (USML-1) mission. The first 16-day mission is planned on USML-2 in FY 1995. Beginning in 1994, NASA plans to initiate an expansion of the EDO program. The objective is to support flights of up to 30 days. The benefits of the program are: (1) to allow the capability of obtaining long-duration life science studies extending human presence in space and, (2) extending crew interaction with basic life sciences and materials research. The plan is to procure a second pallet system and to modify Endeavour and Atlantis with an enhanced autoland capability (auto braking, nose wheel steering upgrades, and a disengage switch) along with various other upgrades to support these longer stay times. The necessary upgrades to utilize Spacelab for these missions are included in the Spacelab budget.

The structural spares program has been rebaselined to focus on high-risk spares such as payload bay doors, elevons, body flaps, and other items susceptible to damage. The production of major structures such as the aft fuselage and the mid-body are no longer planned. However, this rebaselined program, together with other tasks at the prime contractor facilities (e.g. - Mir, EDO, the Orbiter Maintenance Down Period (OMDP) on OV-104 performed at Palmdale this year, etc.), should retain some manufacturing skills.

Systems integration tasks include the continuing development of the Program Compliance and Assurance System (PCAS) which is a comprehensive Shuttle data base that examines failure histories across all the Shuttle elements. Also included are contingency landing and abort analyses to support full utilization of existing orbiter capabilities.

Orbiter spares comprises certification of the NASA Shuttle Logistics Depot (NSLD) to repair hardware previously serviced by Original Equipment Manufacturers (OEMs). Standard and automated test equipment, maintenance manuals and other items are covered. This activity is being concluded this year.

<u>CHANGES FROM FY 1993 BUDGET ESTIMATE</u>

Overall, Orbiter Operational Capability decreased $8.5 million in FY 1993. To partially accommodate a general reduction of $60 million to Shuttle Production and Operational Capability directed by Congress, funding for unanticipated program changes was reduced $50.8 million. This reduction was partially offset by increased requirements to conduct the OMDP on OV-104 at Palmdale instead of at the launch site as well as $37.5 million to fund requirements to support the Mir mission. A reduction in the structural spares program was also made in response to Congressional action and this program was subsequently rebaselined.

BASIS OF FY 1994 ESTIMATE

Orbiter operational capability supports the development and implementation of improvements to the orbiter fleet for the enhancement of safety, operations, performance, and economy. Tasks to be continued in FY 1994 include improvements to Auxiliary Power Unit components such as the Gas Generator Valve Module (GGVM); continuing analysis of the external tank debris experienced during separation; upgrades to the Remote Manipulator System (RMS) servo-power amplifier to accommodate heavier loads; upgrades to the rate gyro assembly which is also used in the Solid Rocket Booster (SRB); and various orbiter support tasks such as Orbiter Manuevering System/Reaction Control System (OMS/RCS) testing at White Sands, modifications to the RMS, and support to the Crew Escape System.

In order to support an FY 1995 mission to Mir, activity in FY 1994 will include completion of the development and qualification testing on the Russian docking mechanism by Rockwell as well as initial work on integrating this hardware into the cargo bay. The integration includes incorporation of an external airlock, being developed under the Payload Operations budget, along with a transfer tunnel to accomplish docking. During the OMDP on Atlantis at Palmdale in FY 1993, an EDO kit (minus a cryo pallet) will be installed and used on the Mir mission. Atlantis will be retained at Palmdale until mid-FY 1994 to install 30 day extended duration orbiter (EDO) capability.

EDO funding covers the payback costs to the prime contractor for use of the cryogenic pallet kit to extend on-orbit stay time capability from the baseline 7-10 days to 14-16 days. The pallet development and production were undertaken through a private financing agreement between NASA and Rockwell International. The agreement provides for recovery of investment with pallet use. Funding in FY 1994 initiates the required modifications on Endeavour and Atlantis which will be the 30-day EDO vehicles. Modifications to be included are redundant heaters, upgrades to the communications, and some hydraulic subsystem upgrades. In addition, development of a new long-life fuel cell will be started in FY 1994. Not only is a longer life fuel cell a key factor to ensure extended on-orbit operations, but it also lessens the frequency of changeouts and lowers overall maintenance, particularly if an external airlock is ultimately used. Ultimately, between what is funded in this program and in Payload Operations in the R&D appropriation, there will be three orbiters with pallet interface capability (i.e.- OV-102, OV-105, and OV-104), two external airlocks, two cryogenic pallets, 2 LDO kits, and a docking mechanism system.

For the structural spares program in FY 1994, work will continue on the vertical tail, the elevons, main landing gear doors, payload bay doors, body flap, external tank (ET) and nose gear doors, OMS skins, and wing parts. These are hardware items with a higher risk of potential damage. The OMS skins and wing parts should be completed by the end of FY 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

PROPULSION SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Space shuttle main engine (SSME).......	322,100	314,600	263,200	245,400
Solid rocket booster (SRB).............	34,900	43,100	30,200	52,500
Total...........................	357,000	357,700	293,400	297,900

OBJECTIVES AND STATUS

The Propulsion Systems budget provides for the production of the SSMEs and the development of the safety, reliability, and producibility enhancements needed to support operational requirements for both the SSME and the SRB.

The SSME program funds development and certification activities to improve engine operating margins, safety, reliability, and durability, as well as to make the engine easier to produce and maintain. The major improvements currently in work are the single-coil heat exchanger, the Phase II+ powerhead, the Alternate Turbopumps (both LOX and Fuel), and the Large Throat Main Combustion Chamber. These improvements will effectively double the overall Shuttle safety margins once they are completed. Although the development and implementation of the Alternate Turbopumps and Large Throat Main Combustion Chamber are funded under the Safety and Obsolescence Upgrades budget, testing for development and certification of these improvements is funded under this budget.

The current heat exchanger is the number one item on the list of SSME critical safety risks. The single-coil heat exchanger, currently in development, will substantially increase the safety of the engine. The heat exchanger, mounted in the powerhead, uses the hot, hydrogen-rich, gas (800° - 900° F) exiting the LOX turbine to convert liquid oxygen to gaseous oxygen for pressurizing the ET oxygen tank and the POGO suppression system. The current heat exchanger has a primary tube that splits into two secondary tubes at a bifurcation joint inside the powerhead. This joint is welded to the tubes in a difficult process that cannot be fully inspected once installed into the engine. There is a concern that over extended operations, the heat exchanger could develop oxygen leaks at the welds, or through the extremely thin tube walls (as little as 1/80 of an inch thick). Even a tiny leak of oxygen into the hot hydrogen gas would rapidly cause destruction of the engine. The single-coil heat exchanger has no welds exposed to the hot gas, and has tube walls about three times thicker than in the current design.

The SSME powerhead is the backbone of the engine. It connects the two preburners powering the high-pressure turbopumps with the main propellant injector through a hot-gas manifold, and contains the heat exchanger as well as the attachment points for the high-pressure turbopumps and the main combustion chamber (MCC). The current hot-gas manifold links the main injector to the fuel preburner with three ducts and to the oxidizer preburner with two ducts. This configuration yields hot gas flows with non-uniform pressures and velocities, as well as large pressure drops, conditions which place high dynamic loads on main injector elements and reduce engine performance. In addition, the significant pressure drop in hot gas flow in the ducting from the fuel turbine to the main injector places large lateral loads on the sheet metal structure in the high-pressure fuel turbopump. The current powerhead is constructed with a large number of welds, making it difficult to produce and raising concerns about quality, reliability, and long-term durability and safety. The Phase II+ powerhead addresses the issues with the current design by using a two-duct configuration between the fuel pump and the main injector to significantly improve the hot gas flow characteristics, and by reducing the number of welds by 24 percent. Testing on the Phase II+ powerhead with the single-coil heat exchanger began in 1992, with certification testing scheduled to be completed in mid-1995.

The SSME Propulsion Systems funding is provided for contractor test and engineering manpower and for hardware. The hardware procured includes spare parts for test engines, newly designed components like the two-duct hot-gas manifold and the single-coil heat exchanger, and new engines to replace those in the test fleet that reach their life limits. The SSME project support and other support, also funded in Propulsion Systems, pay for NASA supporting engineering at the Marshall Space Flight Center (MSFC), support contractor work at the Stennis Space Center (SSC), test propellants at MSFC and SSC, and special analysis and studies at the Lewis Research Center (LeRC).

Although the redesign of the SRB to resolve deficiencies in the previous design was completed in FY 1988, efforts to increase safety margins continue and are funded in the Propulsion Systems budget. Flight data will be assessed, and recovered flight hardware will be inspected, to ensure that the boosters are performing as designed. In addition, SRB project support efforts at MSFC are funded under Propulsion Systems.

CHANGES FROM FY 1993 BUDGET ESTIMATE

FY 1993 funding requirements in Propulsion was reduced $64.3 million to accommodate the general reduction directed by Congress as well as to offset increased requirements within Shuttle Production and Operational Capability. The decrease in the main engine program is attributed to a reduction in testing that lowered manpower, hardware, and propellant costs. Other decreases in the main engine funding for FY 1993 are due to reductions in allowances for change traffic as well as the availability of FY 1992 funds. SRB funding has decreased due to the deferral of the asbestos-free program on the Redesigned Solid Rocket Motor (RSRM) and a re-estimate of costs associated with the Technical Evaluation Motor (TEM) firings.

BASIS OF FY 1994 ESTIMATE

SSME funding in the FY 1994 budget supports the continued development, testing, material procurement, fabrication, and engine assembly operations necessary to support the flight and ground test programs. The SSME ground test program is based on an average test rate of eight tests per month (460 seconds duration) through FY 1994. The primary purpose of this testing is to develop and flight-certify improved hardware like the Phase II+ Powerhead (two-duct hot-gas manifold), the single-coil heat exchanger, and the Alternate Turbopump. Ground testing will also be performed on all new or recycled flight hardware prior to acceptance. Other testing will be utilized to provide hot-fire experience and increase life limits on flight-configured engines. Beginning in FY 1994, funding for the Technology Test Bed will be transferred to the Engineering and Technology Base (ETB) program. The test bed is an institutional capability allowing improvements across a wide range of programs including the SSME. With the completion of certification testing on the single-coil heat exchanger and the Phase II+ powerhead, as well as the stabilization of the engine design, the SSME program intends to close one of the three test stands (test stand B-1) now in use at the Stennis Space Center in FY 1995. The two remaining stands will be used for acceptance tests of new and recycled hardware, for flight certification of upgrades such as the Large Throat Main Combustion Chamber (LTMCC), and for tests to extend hardware life limits. New attrition engines will continue to be produced in FY 1994 to support deliveries in FY 1995 and FY 1998. The Block II controller, which was flown for the first time in FY 1992 on Endeavour's maiden voyage, is expected to complete production in 1993, with 1994 funding to be used to buy initial spare parts and test equipment. However, the other significant upgrades, such as the Phase II+ and the single-coil heat exchanger, have hardware procurements in FY 1994.

FY 1994 funding for the SRB supports continued efforts to improve the safety and producibility of the SRB, including the RSRM. Booster funding includes: a redesign of the C-Band transponders used during booster recovery; a program to increase launch safety margins by developing a design modification which will decrease stress in critical aft skirt welds; and the design of a new test set for the integrated electronics assembly. Due to the restructure of the ASRM and its associated delay into the Shuttle program, an asbestos-free RSRM will be implementated in 1997. FY 1994 RSRM funding also pays for motor ground tests and for disposal of Filament Wound Cases (FWC) produced and filled with propellant in the mid-1980s before the termination of the lightweight composite case effort. SRB project support activities at MSFC needed to support these development efforts will continue.

BASIS OF FY 1994 FUNDING REQUIREMENT

ADVANCED SOLID ROCKET MOTOR (ASRM)

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Advanced solid rocket motor (ASRM).....	315,000	--	195,000	280,400
(Included in Construction of Facilities (CofF) budget)..........	(150,000)	(--)	(165,000)	(32,600)

OBJECTIVES AND STATUS

The objectives of the ASRM program are to improve the system safety and reliability of the Shuttle while increasing payload lift capability. These objectives are achieved in the following ways: (1) a better motor design that reduces hot gas leak paths by 88 percent, (2) a reduction in the number of segments from four in the RSRM to three, (3) use of welded factory joints, (4) field joints designed to close under operating pressure,(5) decreased SSME throttling requirements provide significant system enhancements and benefits particularly for engine-out scenarios, (6) a highly automated manufacturing process that minimizes variations in production and enhances quality control, and (7) using a non-asbestos insulation which eliminates the risks associated with asbestos. Payload lift capability will be increased by 12,000 pounds due to the larger diameter of the motors and the use of a higher performance propellant.

The ASRM will be maufactured in a new, environmentally friendly, advanced state-of-the-art production plant. Among the key features in the production process are a continuous mix and cast propellant process, use of robotics, automated process controls, and closed loop control of production by-products. The advanced technology should ensure the highest possible worker safety, motor reliability, and environmental protection during operations.

The ASRM design and development is well underway. Since the prime contract was signed in May 1990, a successful motor Preliminary Design Review (PDR) was held in February of last year. The facility design is essentially complete and the construction is 55 percent complete. All environmental permits are in place and plant equipment designs are essentially finished with a significant amount of equipment procurements currently being completed. All planned propellant continuous mix pilot plant tests have been successfully accomplished. Seven 48 inch subscale motors have been test fired to evaluate insulation and characterize nozzle materials. Full scale case segment articles are in various stages of completion. Case segment factory welding and heat-treat of the Transient Pressure Test Article (TPTA) is underway. The goal of achieving an additional 12,000 pounds of lift capability continues to be attainable and the ASRM is currently scheduled for a first flight before the end of calendar year 2000.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Due to the tight budget environment, constrained outyear funding projections, and other factors the ASRM was not included in the FY 1993 budget request. Congress reinstated funding for the ASRM in NASA's FY 1993 appropriation. However, the funding level directed in the Conference Report (House Report #102-389) accompanying the FY 1993 VA-HUD-Independent Agencies Act (PL #102-389) was lower than that for the previous year. In addition, the program experienced some internal delays. The program was rebaselined for a later first flight date. In order to continue the program at the lower funding levels, many actions are being undertaken in FY 1993. The Thiokol contract was terminated with a proposal for specific tasks requested. Babcock and Wilcox, the supplier of the case segments, reduced its FY 1993 production while Lockheed-Austin was reduced consistent with the restructure. Other awards were also delayed such as the nozzle facility building at Michoud, the barge dock at Yellow Creek, the Rotation, Processing, and Surge Facility (RPSF) at KSC, and some test stands at MSFC.

BASIS OF FY 1994 ESTIMATE

Consistent with overall agency funding constraints, the ASRM schedule has been further adjusted to match funding availability in FY 1994 and future years. First launch of the Shuttle utilizing ASRMs is now planned at the end of calendar year 2000.

Throughout FY 1994, work will continue in the areas of facilitization and activation, process verification including soluble core, motor case manufacturing, and systems engineering. Unawarded contracts delayed from the current year will be awarded. The final assembly and mix/cast facilities will progress towards start-up milestones in 1993 and 1994, respectively. The case preparation facility will be ready for use in mid-1994. Originally, the first Developmental Motor (DM-1) static test firing was to commence at the end of 1994, but under the restructured program the DM-1 firing will not take place until mid-1998. The Transient Pressure Test Article (TPTA) and the modal survey will be slipped to the 1998 time frame. Motor manufacturing needed to support these milestones is being delayed consistent with the restructured schedule. The Critical Design Review (CDR) originally scheduled for February 1995 will be deferred until July 1998. An Interim Critical Design Review (ICDR) is scheduled in August 1995.

BASIS OF FY 1994 FUNDING REQUIREMENT

LAUNCH AND MISSION SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Launch site equipment (LSE)............	93,100	86,000	69,000	68,500
Mission support capability.............	148,100	124,700	109,100	105,400
Total...........................	241,200	210,700	178,100	173,900

OBJECTIVES AND STATUS

This activity supports the development of launch and mission support capabilities, principally at the Kenndy Space Center (KSC) and the Johnson Space Center (JSC).

The major operational Space Shuttle facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC), and three Mobile Launch Platforms (MLPs). These facilities support the prelaunch and post-landing processing of the four orbiter fleet. Key enhancements funded in Launch Site Equipment include: development and implementation of a digital operational intercom system (OIS); replacement equipment for the Launch Processing System (LPS); an improved Checkout, Control, and Monitoring System (CCMS II); a Shuttle Processing Data Management System (SPDMS); a Launch Team Training System (LTTS); fiber optic cabling; and the Launch Equipment Test Facility (LETF) support.

The mission support capability budget funds JSC projects to improve capabilities or replace obsolete equipment such as: the Mission Control Center (MCC) equipment upgrade; the flight and ground support training facility improvements; and the flight design systems enhancements. Necessary improvements are being made in simulation training in both the Shuttle Mission Simulator (SMS) and the MCC. SMS upgrades include new host computers, interface hardware and simulator subsystems. The MCC will have improved console operations and communication equipment as well as new data processing and distribution systems. Critical improvements in simulation fidelity will be accommodated with the expanded capacity of the new hardware. Reliability required for the longer integrated simulations, and associated maintenance cost, will also be substantially improved with these replacements.

Other activities funded in mission support capability include implementing required modifications and upgrades on the T-38 aircraft used for space flight readiness training, modifications needed for the replacement Shuttle Training Aircraft, capability improvements for weather prediction, and enhancements on information handling to improve system monitoring, notably for anomaly tracking.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Launch and Mission Support total has decreased $32.6 million. Launch Site Equipment (LSE) has decreased by $17.0 million due to a reassessment of the upgrade to the CCMS-II, re-estimate of the costs to provide the LTTS and the improved SPDMS. Mission support capability has decreased $15.6 million due to a delay in modifying the Shuttle Training Aircraft replacement until 1995, a re-estimate of MCC and SMS upgrades due to rephasing and cost savings initiatives, and rephasing of the T-38 upgrades to reflect actual modification start dates.

BASIS OF FY 1994 ESTIMATE

At KSC, funding is required to continue the upgrade of the CCMS II. The CCMS-II is part of the launch processing system that performs the real-time checkout, control, and monitoring for Shuttle processing. The current system is over 20 years old and has gone without any major technology upgrades for almost 15 years. CCMS-II is currently in the post-CDR phase with deliveries to begin in FY 1994. The development should be complete by 1996 and full implementation is planned in 1998. In addition, other necessary upgrades and equipment replacements will be continued such as an orbiter ground cooling system, improved hazardous gas detection system, and improvements to the launch computer complex.

At JSC, major equipment upgrades in the MCC will continue with the replacement of aging equipment, such as the data processing and distribution system. Major subsystem upgrades in the SMS will continue with the acquisition of host and base interface computer replacements for the fixed and motion-based simulators. Associated software rehosting efforts and planning towards replacement of the instructor operator stations will take place as well. Funding supports the continuation of avionics upgrades to the fleet of T-38 aircraft as well as landing aids at the contingency/abort landing sites. In addition, the T-38s are undergoing structural and safety upgrades to prolong the aircraft service life through the auspices of the Air Force T-38 Pacer Classic program.

BASIS OF FY 1994 FUNDING REQUIREMENT

SAFETY AND OBSOLESCENCE UPGRADES

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Alternate turbopump	80,200	81,800	50,100	67,800
Multifunction electronic display system	15,100	21,900	12,000	34,400
Hardware interface module replacement	2,600	3,600	3,000	6,000
Cable plant upgrade at Kennedy Space Center	600	7,100	6,900	10,000
Large throat main combustion chamber	--	--	7,100	22,000
Studies/new candidates	6,100	24,500	10,400	--
Total	104,600	138,900	89,500	140,200

OBJECTIVES AND STATUS

In order to assure that the U.S. maintains a viable manned transportation capability into the next century, specific program investments are required. The Safety and Obsolescence Upgrades program, previously titled Assured Shuttle Availability (ASA), funds the necessary improvements on the Shuttle needed to expand existing safety margins as well as to ensure continued safe and reliable Shuttle operations by addressing obsolete systems. Improved flight turnaround times and reduced operational costs are also benefits of this program. In the past, these kinds of improvements have been added incrementally as individual items of hardware experienced problems or vendors could no longer supply older components. These types of requirements will increase as the Shuttle system ages and safer ways of operating the Space Shuttle are identified.

The management approval process utilized in the program will ensure that improvements are evaluated and approved on a priority basis across the entire Shuttle program. The orbiter vehicle, other elements of flight hardware, ground processing facilities, and other supporting systems, will all be considered in the implementation of this program.

The schedule for development and installation of orbiter-related improvements is designed to take advantage of the planned intervals when orbiters are scheduled to be taken out of service for structural inspections and modifications. This plan provides for an orderly development and implementation program and minimizes interruption of the flight program. Specific, large improvements which exceed a total cost of $15.0 million will be funded from this program. Smaller improvements and modifications will continue to be funded in the individual projects.

The most challenging and troublesome components of the Space Shuttle Main Engine (SSME) are the high pressure turbopumps. Engine system requirements result in pump discharge pressure levels between 6000 to 8000 psi and turbine inlet temperatures in excess of 2000 degrees. In reviewing the most critical items on the SSME that could lead to a catastrophic failure, 14 of the top 25 are associated with these turbopumps. Moreover, the turbopumps are difficult to manufacture and require extensive inspections and frequent removal for overhaul and retest. Over the years, the current turbopumps have been the source of several flight delays and many ground test failures including some that were catastrophic. While remedies have been sought to address the continuing problems with the turbopumps, it was concluded in 1985 that a complete redesign was necessary. These new pumps are referred to as the Alternate Turbopumps (ATP).

The ATP incorporate state-of-the-art technology designs intended to address the shortcomings of the current SSME high-pressure turbopumps. The pumps use precision castings, fewer parts, stiffer shafts, and better bearings than the current pumps, and the number of welds is reduced from 769 to 7. All uninspectable welds are eliminated. With these improvements, the pumps should provide increased supportability, greater safety margins, and a longer operating life than the current pumps. A number of technical problems have plagued the liquid oxygen (LOX) pump, including turbine inlet cracking, turbine bellows cracking, and high synchronous vibration anomalies. Design changes have been implemented and successfully demonstrated. The most recent technical issue, pump-end ball bearing wear, has required numerous pump rebuilds and engine testing to resolve. Testing has shown that damper seal radial support softening coupled with stiffened housings, improved coolant distribution, optimize cage designs, and potentially the use of silicon nitride ball bearings, may have resolved this issue. One LOX pump has successfully completed six full duration mission simulation tests, while another design has successfully completed over 2500 seconds of testing. Testing has included nominal mission duration and power level, as well as abort duration (14 minutes) and 109 percent abort power level. Additional units will be tested in the near future, and should complete the resolution of the ball bearing anomaly. Consistent with direction contained in House Report 102-226, NASA assessed the merits of continuing development of the Alternate Fuel Pump. Development activities on the fuel pump were suspended so that effort could be focused on the more critical LOX pump. When the LOX pump is successfully developed, NASA will report results of the effort to Congress and then resume development efforts on the fuel pump. Based on the current schedule, this resumption would occur in FY 1995. First flight using the LOX pump is planned for June 1995 and the first flight using the fuel pump is scheduled in FY 1998.

The Multifunctional Electronic Display System (MEDS) upgrade will allow replacement of the 1970s display technologies which are embedded in the orbiter cockpit. The current display system, which provides the pilot and commander with vehicle flight control and with the interface to the orbiter data processing system, is a single string electro-mechanical system. This system is proving to be particularly susceptible to life-related failures. The upgrade will provide both a new architecture and the flight equipment to enhance the reliability of the system and will resolve the parts availability problems. The new display system will bring the orbiter up to current aircraft standards which will have a direct benefit on training of new astronauts while also providing the potential for enhanced information flow during operations. The MEDS upgrade includes the design effort and the production of additional modification kits for the four vehicles. New ground support hardware will also be designed, procured, and installed to upgrade the appropriate simulators, test equipment, and laboratories. MEDS consists of two phases. Phase one will incorporate a multi-functional cathode ray tube display system consisting of 4 display units, 4 data processors, and 2 panel assemblies. The first flight utilizing these changes is planned in 1996. Phase two incorporates flight instrumentation and system status meters including additional panel assemblies, display driver units, and other hardware. The first flight incorporating these improvements is planned in FY 1998.

The Hardware Interface Module (HIM) cards at KSC are now obsolete and have caused an increased failure rate and repair cost over the past several years. The HIM upgrade will replace all chassis and cards with state-of-the-art "off the shelf" hardware to improve system reliability and maintainability. The design reviews were completed in FY 1992, procurement was initiated in FY 1993, and these systems should be completed by FY 1998.

The cable plant upgrade at KSC has been initiated to replace the miles of cables which support a wide variety of Shuttle facilities. Many of these cables were installed in the 1960s and are beginning to suffer increasing failure rates. Replacement will reduce the potential for disruption to critical Shuttle operations as well as have a direct maintenance benefit. This will reduce the possibility of launch delays, increase communication system spares availability, and enhance the reliability of data, instrumentation, voice, and video communications. This upgrade will replace the wideband distribution systems and the lead/antimony sheath cables installed at that time with fiber optics and plastic sheath, gel-filled cable. In addition, many field terminations will be replaced or upgraded as well as the manhole system. Other obsolete systems will also be replaced with current technology.

The SSME's staged combustion cycle and high main combustion chamber pressure (~3000 psi) result in extremely stressful internal operating conditions such as high turbine discharge pressures and temperatures, and high turbopump shaft speeds. In order to alleviate these conditions, a new project is proposed for FY 1994 entitled the Large Throat Main Combustion Chamber (LTMCC). The LTMCC differs from the current Main Combustion Chamber in several ways. The throat diameter is increased 11 percent which lowers the chamber

pressure by 9 percent. The contour of the chamber also allows an increase in the number of coolant channels, thereby reducing the operating temperature of the hot wall inside the MCC and increasing the MCC's life as well as reducing the potential for pin hole leaks and coolant channel cracks. The operating conditions discussed above are lowered by as much as 10 percent in some cases. Use of the LTMCC allows the SSME to operate at lower stress levels which directly enhances safety margins. For example, operating the LTMCC configuration at 104 percent of its Rated Power Level (RPL) is equivalent to using the current MCC at 100 percent RPL. This improvement, coupled with ongoing SSME upgrades will improve the Shuttle safety margins by a factor of two. The development program will consist of four units for testing purposes along with the purchase of the necessary units for fleet retrofit. The LTMCC program will also include the required modifications to the other elements of the SSME as well as any incremental support required by the test program. A first flight utilizing the new LTMCC is planned for FY 1998.

In FY 1993, the Safety and Obsolescence Upgrades budget also includes funding to support ongoing studies focused on the replacement of environmentally restricted materials as well as other potential items such as a simplified OMS/RCS and incorporation of the Global Positioning System (GPS) into the orbiter. None of these items will be developed until they have been fully assessed including technical approach, cost requirements, and schedule considerations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The Safety and Obsolescence Upgrades budget has been decreased $49.4 million. Of this amount, $31.7 million is due to deferring implementation of the LOX pump on the ATP program. This delay is the result of the decision to more fully assess the outcome of the test program on the LOX pump before proceeding with its implementation. The MEDS for the orbiter cockpit has been decreased $9.9 million due to a reestimate of the phasing required to support its development. Both the HIM card replacements and the cable plant upgrade at KSC have been rephased. The LTMCC will be initiated this year in order to achieve our safety improvement goals. Funding for new studies and candidates was reduced to accommodate overall reductions in resource availability.

BASIS OF FY 1994 ESTIMATE

Alternate Turbopump (ATP) funding in FY 1994 supports development and certification testing of the high pressure liquid oxygen (LOX) pump, with certification expected to be complete by mid-1995 and first flight during that year. ATP fuel pump development funding supports continued caretaker status for an additional year. ATP implementation funding procures LOX pumps to outfit the engine fleet. However, both LOX and fuel pump production have been delayed one year from the previous budget, with the funding reduced accordingly. Initial flights of the LOX pump will use production verification pumps funded in the development effort. In FY 1994, MEDS will conduct its Critical Design Review (CDR). The MEDS prime contractor, along with the subcontractors, will also continue the building of prototype units in preparation for systems integration

testing to be started in FY 1994 and leading to the first use of this system in FY 1996. It is planned that the installation and checkout of the MEDS into the orbiter fleet will take place in such a manner that all of the four orbiters will be modified during the in-line flow process at KSC. The HIM card project will have a CDR in FY 1993 for the hardware/software integration and validation. Contracts will be awarded for the first hardware production units to be delivered in FY 1994. The KSC cable plant upgrade will involve design reviews in FY 1993 prior to replacing the cable network running from the Launch Computer Complex to the Orbiter Processing Facility. the launch pads and the vehicle assembly building. Casting development for the LTMCC will be completed by the end of FY 1994. The first LTMCC with a cast manifold should be ready for hot-fire development testing by the end of the fiscal year. This unit will be the first of four LTMCCs fabricated in FY 1994 for development and certification testing. The other three units will be delivered in FY 1995. The wedge for studies and potential new candidates has been removed to accommodate funding availability for FY 1994.

BASIS OF FY 1994 FUNDING REQUIREMENT

SPACE SHUTTLE OPERATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Flight operations......................	807,900	740,400	752,117	767,800	SF 2-3
Flight hardware........................	1,326,800	1,455,300	1,398,153	1,364,600	SF 2-5
Launch and landing operations..........	642,900	639,900	690,800	696,400	SF 2-7
Research operations support............	251,700	279,600	174,883	177,700	SF 2-9
Total..........................	3,029,300	3,115,200	3,015,953	3,006,500	

Distribution of Program Amount by Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Johnson Space Center...................	866,700	904,500	864,500	897,200
Kennedy Space Center...................	947,100	946,700	982,500	978,300
Marshall Space Flight Center...........	1,123,800	1,150,900	1,065,700	1,088,800
Stennis Space Center...................	12,400	12,600	13,500	13,400
Ames Research Center...................	5,900	5,800	6,700	6,300
Headquarters...........................	73,400	94,700	83,053	22,500
Total..........................	3,029,300	3,115,200	3,015,953	3,006,500

OBJECTIVES AND STATUS

Space Shuttle Operations provides launch services to NASA payloads as well as to other civil agencies and certain commercial and international users, on a reimbursable basis. The Shuttle operations budget is based on a planned rate of eight flights per year.

The Space Shuttle has demonstrated a broad range of capabilities including deployment of spacecraft and their upper stages, satellite repairs, satellite retrieval, operations using the remote manipulator, integral scientific experimentation using Shuttle and Spacelab systems, and extravehicular activity operations. These capabilities provide a unique national resource that enhances the scientific reward of many payloads. The major program elements of Shuttle Operations are Flight Operations, Flight Hardware, Launch and Landing Operations, and Research Operations Support.

Both the current estimate for FY 1993 and the budget estimate for FY 1994 reflect the redistribution of the Research Operations Support (ROS) funding. This restructuring charges the various NASA programs the cost of activities that directly support or benefit these programs. In Shuttle Operations, approximately $84 million worth of tasks have been reallocated to the benefitting programs.

The Space Shuttle program is aggressively continuing the major thrust initiated in FY 1992 to dramatically reduce the cost of operations. Shuttle funding in FY 1993 and FY 1994 reflects program efficiencies and content reductions of 20 percent and 22 percent respectively when measured from the baseline of the FY 1992 President's budget. Since that time, over $900 million has been removed from the Shuttle program in FY 1993 and over $1.0 billion from FY 1994. These reductions are realized after the ROS restructuring is taken into account. This represents a significant challenge for the Shuttle program, the various project offices, and the Shuttle contractors. Although the majority of these savings have been identified by specific actions, a substantial unresolved reduction remains in FY 1994. The program management is confident that the reductions can be achieved and will work aggressively towards that end.

As in the past, Shuttle Operations requirements are funded through a combination of funds received from Congressional appropriations and reimbursements received from customers manifested on the Shuttle. Planned reimbursements in FY 1993 are $45 million and in FY 1994 they are $60 million.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In total, funding for Shuttle Operations has decreased $99.2 million. This net reduction is the result of a reduction in funding for Research Operations Support (ROS) of $20 million as directed by Congress, and a further reduction in content of $90 million, offset by an increase of $20 million in launch and landing operations for increased labor rate costs. The reduction of $90 million in program content is accommodated primarily by reduced funding requirements for the External Tank due to efficiencies implemented in that program, as well as reduced manpower requirements for flight integration and software activities.

BASIS OF FY 1994 FUNDING REQUIREMENT

FLIGHT OPERATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission operations....................	295,900	338,400	329,117	330,900
Integration...........................	315,400	163,000	146,000	151,700
Support...............................	196,600	239,000	277,000	285,200
Total...........................	807,900	740,400	752,117	767,800

OBJECTIVES AND STATUS

Flight operations is divided into three major areas of activity: mission operations, integration, and support. Mission operations includes a wide variety of preflight planning, crew training, and operations control activities. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include: flight planning; preparing systems and software handbooks; defining flight rules; creating detailed crew activity plans and procedures; developing and establishing the Mission Control Center (MCC) and network system requirements for each flight; and contributing to planning for the selection and operation of Shuttle payloads. Flight planning encompasses flight design, flight analysis, and software activities. Both conceptual and operational flight profiles are designed for each flight and the designers also help to develop crew training simulations and flight techniques. In addition, the flight designers must develop unique, flight-dependent data for each mission. The data is stored in the erasable memories located in the orbiter, Shuttle mission simulator, and MCC computer systems. Mission Operations funding also provides for the maintenance and operation of critical mission support facilities including the MCC, flight simulators, crew training, and flight software support facilities. Finally, beginning in FY 1993 mission operations includes maintenance and operations of aircraft needed for flight training and crew proficiency requirements. Previously, aircraft operations had been funded under support.

Integration includes payload integration into the Shuttle and system integration of the flight hardware elements. Payload integration covers the engineering analysis needed to ensure that various payloads can be assembled and integrated to form a viable cargo for each Shuttle mission. Systems integration covers the necessary engineering tasks to ensure that the system can be safely launched. Prior to FY 1993, orbiter

sustaining engineering had been funded under the integration budget. Beginning in FY 1993, this activity was placed under orbiter flight hardware to make it consistent with the other flight hardware elements which include their sustaining engineering. In addition, flight software development was transferred from Integration to Support beginning in FY 1993 so that the Integration budget captures only those elements managed by the Space Shuttle Program Office.

Support covers the engineering tasks at the Johnson Space Center (JSC) that support the Shuttle and now includes flight software development and verification. The software activities include development, formulation, and verification of the guidance, targeting, and navigation systems software in the orbiter. Support also includes the Shuttle share of the multi-program support at the manned centers.

CHANGES FROM FY 1993 BUDGET ESTIMATE

FY 1993 funding for the Flight Operations budget increased by $11.7 million. An additional $43.3 million was added to Flight Operations due to a transfer from the Research and Operations (ROS) budget. This transfer is based on restructuring ROS to fund administrative operations at the Centers and to align appropriate cost to benefitting programs. Reductions in engineering integration and payload integration manpower as a result of increased efficiencies stemming from cost reduction efforts underway within Shuttle Operations offset most of this increase. In addition, flight software support and planned upgrades have been reduced based on a reassessment of software requirements. Finally, allowances for unanticipated changes were reduced based on a re-estimate of change traffic.

BASIS OF FY 1994 ESTIMATE

The Flight Operations portion of the Shuttle Operations budget primarily supports efforts at JSC to plan for and conduct Shuttle missions from launch to landing. The functions are essentially the same as in the past: to maintain and operate all the ground facilities necessary for flight preparation and execution; to instruct the flight and ground controller crews; to maintain the proficiency and readiness of operational aircraft for training and orbiter ferry requirements; and to provide real time support to each Shuttle mission. Support will be provided to the missions to be flown in FY 1994 and to the initial efforts for flights in FY 1995 and FY 1996. These projects will continue their reductions into the outyears by critically reviewing their current requirements and identifying new ways of doing business in order to determine the minimum resource level needed to support the manifest without compromising flight safety.

BASIS OF FY 1994 FUNDING REQUIREMENT

FLIGHT HARDWARE

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Orbiter	430,700	522,700	540,853	508,900
Solid rocket booster (SRB)	542,000	556,700	559,100	515,700
External tank (ET)	354,100	375,900	298,200	340,000
Total	1,326,800	1,455,300	1,398,153	1,364,600

OBJECTIVES AND STATUS

The Flight Hardware budget buys the major hardware elements that are launched with the Shuttle and the sustaining engineering to support this hardware. This line includes funding for various orbiter items including the main engines along with the deliveries of solid rocket boosters (SRB) and external tanks (ET).

Orbiter flight hardware consists of the following items: (1) Orbiter spares for the replenishment of Line Replacement Units (LRUs) and Shop Replacement Units (SRUs) along with the manpower required to support the orbiter logistics program; (2) production of ET disconnect hardware; (3) overhaul and repair of main engine components, procurement of main engine spare parts, and main engine flight support and anomaly resolution; (4) flight crew equipment processing as well as flight crew equipment spares and maintenance; and (5) various orbiter support hardware items such as pyrotechnic initiated controllers (PICS), NASA standard initiators (NSIs), and overhauls and repairs associated with the Remote Manipulator System (RMS). In addition, beginning in FY 1993, the sustaining engineering associated with the orbiter vehicles is now included in this budget line. Previously, orbiter sustaining engineering had been funded under the integration line in the Flight Operations budget.

SRB funding covers deliveries of the Redesigned Solid Rocket Motor (RSRMs) as well as the deliveries of the SRB forward and aft assemblies. The RSRM budget includes: (1) purchase of solid rocket propellant; (2) necessary manpower to repair and refurbish flown rocket segments; (3) manpower to assemble individual case segments into casting segments and other production operations including shipment to the launch site; and (4) engineering manpower required for flight support and anomaly resolution. The remaining SRB budget funds: (1) procurement of new hardware and materials needed to support the flight schedule; (2) work at various vendor locations throughout the country for the repair of flown components; (3) manpower at the prime contractor facility for integration of both used and new components into a forward and an aft assembly; and (4) sustaining engineering for flight support.

c.4.

Although the external tank program is continuing to deliver hardware at a minimum level until the excess inventory of tanks is depleted, production is beginning to ramp up to support increased deliveries required in the outyears. The production of tanks involves the following: (1) procurement of materials and components from vendors; (2) manpower at the Government Owned Contractor Operated (GOCO) facility to manufacture tanks; (3) support manpower and other costs to operate the GOCO facility; and (4) sustaining engineering for flight support and anomaly resolution. In the past year, the contractor has taken major steps to reduce the manpower and costs needed to deliver this hardware.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In total, Flight Hardware funding has decreased $57.1 million. Orbiter flight hardware has increased $18.2 million due to re-estimates of efforts to process crew equipment items between flights, labor rate increases on the main engine, and acquisition of additional logistics items such as fuel cells and mission kits. Partially offsetting these increases have been reductions in orbiter sustaining engineering and backup flight software activities. The SRB funding has increased $2.4 million primarily due to the need to procure long-lead items for the next buy of RSRMs. In addition, the ROS restructure has required more institutional tasks to be funded by the SRB program. A major reduction of $77.7 million in funding for the external tank has occurred due to a variety of factors. The largest contributor to this reduction is in the area of contractor staffing. Specifically, the contractor is planning to reduce his direct and indirect manpower by about one thousand by the end of the calendar year. This reduction is possible because of increased efficiencies realized in the assembly of tanks as well as a critical review of indirect manpower requirements. Fee accrual also decreased due to contract concessions and revisions in fee accrual methodology. The balance of the reduction is due to additional efficiencies in the areas of make versus buy, vendor oversight, and plant operations and project support activities.

BASIS OF FY 1994 ESTIMATE

Requirements for orbiter flight hardware items are based on the flight rate, maintenance schedules, operational usage, repair times, and lead times to procure new hardware or repair flown hardware. Both the SRB and ET requirements in FY 1994 are driven by the planned flight model for not only FY 1994, but the outyears as well. The flight hardware elements have been subjected to a very aggressive cost reduction program as a result of the cost targets agreed to last year and additional cost reductions mandated in the current budget by NASA management. These projects are planning to continue their reductions into the outyears by critically reviewing their current requirements and by exploring new ways of doing business in order to determine the minimum resource level needed to support the manifest without compromising flight safety.

BASIS OF FY 1994 FUNDING REQUIREMENT

LAUNCH AND LANDING OPERATIONS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Launch operations	578,600	581,100	632,000	637,500
Payload and launch support	64,300	58,800	58,800	58,900
Total	642,900	639,900	690,800	696,400

OBJECTIVES AND STATUS

Launch and Landing Operations provides for the manpower and materials to process and prepare the Shuttle flight hardware elements for launch as they flow through the processing facilities at Kennedy Space Center (KSC). Standard processing and preparation of payloads as they are integrated into the orbiter are also funded under this category, as is procurement of liquid propellants and gases for launch and base support. Support to landing operations at KSC, Edwards Air Force Base (EAFB) and contingency sites, as required, is also provided.

Operation of the launch and landing facilities and equipment at KSC involves refurbishing the orbiter, stacking and mating of the flight hardware elements into a launch vehicle configuration, verifying the launch configuration, and operating the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation, and inventory management.

In addition, this budget includes other launch support services: the central data subsystem, which supports Shuttle processing as an on-line element of the launch processing system, is maintained and repaired; Shuttle related data management functions, such as work control and test procedures, are funded; equipment, supplies and services are purchased; and operations support functions are provided. Among these support functions are propellant processing, life support systems maintenance, railroad maintenance, pressure vessel certification, Shuttle landing facility upkeep, and equipment modifications. Range support provided by the Department of Defense (DOD) is funded here as well.

Payload and launch support funding provides propellants for launch operations and base support, and contractor support for the assembly of individual payloads into a total cargo. This element includes providing launch site support managers to payload customers and verifying the cargo-to-orbiter interface.

Operations, maintenance and logistics support are provided to cargo support equipment (such as cargo integration test equipment and multimission payload support equipment) and to the payload support areas (the Vertical Processing Facility, Operations and Checkout building, and Cargo Hazardous Servicing Facilities). Support required for maintaining the Dryden Flight Research Facility as a contingency landing site is also included.

CHANGES FROM FY 1993 BUDGET ESTIMATE

Funding requirements for Launch and Landing Operations have increased $50.9 million. The majority of this growth is the result of the Research Operations Support (ROS) restructuring which requires the operation and maintenance of launch complex 39 to be funded by the benefitting program which is Shuttle Operations. The activities now being included, for example, are security, fire protection, and utilities. The balance of the increase (about $19 million) is due to labor rate increases with the Shuttle Processing Contractor (SPC).

BASIS OF FY 1994 ESTIMATE

Launch operations funding in FY 1994 provides manpower and support services necessary for processing launches from KSC. This includes manpower to assemble the SRBs, mate the boosters and tanks, process the orbiter, mate the orbiter to the integrated SRBs and external tank, process and checkout integrated flight elements through launch, retrieve and disassemble the SRBs for refurbishment, and support landing of the orbiter either at KSC, at EAFB, or at a contingency landing site, if required. Funding also supports the manpower required for KSC sustaining engineering, provisioning, logistics, launch processing system operation and maintenance, and maintenance/modification of all other Shuttle-related ground support equipment and facilities including Launch Complex 39. As with the other elements of Shuttle Operations, the launch operations process is being subjected to cost reduction efforts and the contractor is reviewing ways of continuing to reduce manpower while supporting the manifest and maintaining current safety levels.

BASIS OF FY 1994 FUNDING REQUIREMENT

RESEARCH OPERATIONS SUPPORT

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Research operations support...........	251,700	279,600	174,883	177,700

OBJECTIVES AND STATUS

Research Operations Support (ROS) funding provides vital support to the civil service workforce and to the physical plant at the Centers and at NASA Headquarters. This funding supports the basic core administrative functions such as personnel, payroll, accounting, procurement, and legal counsel. It also supports centerwide services for civil service staff, such as mail, telephones, janitorial services, transportation, medical (other than astronaut), security, and fire protection as well as maintenance of roads, grounds, and all requirements of administrative buildings. Funding to support activities which directly benefit the NASA programs are included in the program budgets.

CHANGES FROM FY 1993 BUDGET ESTIMATE

In FY 1992, establishment of the ROS was initially accomplished by transferring funds contained in the Operation of Installation account in the Research and Program Management appropriation to the Research and Development and Space Flight Control, and Data Communications appropriations. During FY 1993, a more detailed examination of activities supported by ROS funding was conducted by the program offices to identify support directly related to program activities. Funding for activities dedicated to a single program was transferred to the benefitting program. A reduction of $47 million consistent with Congressional direction, has been accommodated against all NASA ROS funds. Within Shuttle Operations, the decrease of $104.7 million in ROS funding reflects the transfer of $84.7 million consistent with the restructuring activity and a reduction of $20.0 million consistent with Congressional direction.

BASIS OF FY 1994 ESTIMATE

The FY 1994 estimate is based on the restructuring of the ROS budget in FY 1993 to fund primarily the basic core of administrative functions. In addition, reductions have been implemented to respond to NASA's

internal commitment to holding down costs in all areas and also to the recent executive order mandating reductions in administrative expenses. As such, it reflects the minimum funding to support administrative and facility maintenance requirements at the NASA Centers and NASA Headquarters. This includes administrative services that support all civil service employees, maintenance of roads, grounds, and requirements of administrative buildings.

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Small	32,600	27,900	25,272	26,200
Medium	58,100	67,300	61,451	77,500
Intermediate	45,000	54,800	41,100	63,200
Large	20,100	11,000	5,278	82,300
Upper stages	*(41,200)	56,500	47,700	51,100
Total	155,800	217,500	180,801	300,300

* A non-add. Upper Stages was funded under Space Transportation System (STS) Capability Development prior to FY 1993.

Distribution of Program Amount by Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Kennedy Space Center	8,000	7,300	9,600	10,300
Marshall Space Flight Center	--	55,400	47,301	51,100
Goddard Space Flight Center	83,900	78,800	77,600	93,400
Lewis Research Center	63,900	62,600	46,300	145,500
Headquarters	--	13,400	--	--
Total	155,800	217,500	180,801	300,300

OBJECTIVES AND STATUS

The Launch Services program provides a mixed fleet capability, which in conjunction with the Space Shuttle, satisfies NASA payload requirements. Payloads are assigned for launch on Expendable Launch Vehicles (ELVs) consistent with Shuttle use criteria established in NASA's FY 1991 Authorization Act and the Launch Services Purchase Act of 1990.

With the exception of the launch services being provided for the Cassini mission and some launches procured for the National Oceanic and Atmospheric Administration (NOAA) under a reimbursable agreement, all ELV launch services are being competitively procured by NASA from the private sector, whenever available, to launch civil government payloads in three performance classes:

(a) Small class - payloads up to 1000 lbs. in low Earth orbit
(b) Medium class - payloads up to 10,000 lbs.
(c) Intermediate class - payloads up to 20,000 lbs.

Large class missions with payloads up to 40,000 lbs. to low Earth orbit must be acquired through the Department of Defense (DOD) since no commercially-provided launch services are currently available for this size payload. Since large class vehicles are not available from the private sector, procurement of a Titan IV vehicle and launch services is provided through the U.S. Air Force for the 1997 launch of Cassini.

Beginning in FY 1993, funding required for Upper Stage vehicles is included within Launch Services. The Upper Stages budget includes requirements for the Inertial Upper Stage (IUS) and the Transfer Orbit Stage (TOS). The last TOS vehicle contracted for, in support of the Advanced Communications and Technology Satellite (ACTS) mission, will be launched in mid-1993.

In September 1991, a contract with Orbital Sciences Corporation (OSC) was awarded to provide Small Expendable Launch Vehicle (SELV) services using the Pegasus vehicle. In November 1990, a contract with McDonnell-Douglas was signed to provide Medium Expendable Launch Vehicle (MELV) services using the DELTA II vehicle. A competitive request for proposal will be released in 1993 to provide for a series of potential Intermediate Expendable Launch Vehicle (IELV) missions. These potential missions include the Tracking and Data Relay Satellite (TDRS) system, the Geostationary Operational Environmental Satellite (GOES) series, Earth Observing System (EOS) missions, as well as some potential international cooperative missions.

CHANGES FROM 1993 BUDGET ESTIMATE

The Congressionally-directed reduction of $40.5 million has been accommodated by eliminating all program reserves, postponing all non-essential tasks to FY 1994, and adjustment of some payment schedules for commercial launches. Supporting launch services for all currently-planned launches has been maintained. These adjustments have been partially offset by a $3.8 million increase due to the redistribution of Research Operations Support (ROS) funding.

BASIS OF FY 1994 ESTIMATE

In FY 1994, funding is required for SELVs in order to support the launch of the Total Ozone Mapping Spectrometer (TOMS) and the Fast Auroral Snapshot Explorer (FAST) in 1994. Other missions being supported with SELV funds are the Satellite de Applicaciones Cientificas-B (SAC-B)/High Energy Transient Experiment (HETE) scheduled for a launch in late 1994, and the Submillimeter Wave Astronomy Satellite (SWAS) scheduled for a 1995 launch.

The FY 1994 funding for launches utilizing MELVs include the Wind and Polar missions (1994), the Radarsat cooperative mission with Canada (1994), and the X-ray Timing Explorer (XTE) (1995). The integration and launch costs for three secondary payloads to be launched from the East Coast on DOD Delta II vehicles is also funded. Initial funding is also included for the Advanced Composition Explorer (ACE) mission, the next Explorer mission, scheduled for a 1997 launch.

The majority of the funding required in FY 1994 for Intermediate Class ELVs is for an ATLAS-IIAS in support of the Solar and Heliospheric Observatory (SOHO) mission to be launched in 1995. Also included is funding for the EOS AM-1 mission (1998), including non-recurring costs and other modifications associated with launch and operations at the Western Test Range; and the first ELV-launched TDRS-G (1997). This first launch of the EOS series is planned for 1998.

Large class ELV funding is required for a Titan IV vehicle to support the Cassini mission, scheduled for an October 1997 launch. These funds also support the required Centaur upper stage, with both vehicle elements being purchased as a package from the U.S. Air Force. The Advanced X-ray Astrophysics Facility-I (AXAF-I) mission is currently baselined on the Shuttle for a 1998 launch. However, NASA is also aggressively pursuing an arrangement with the Air Force to use a Titan IV/Centaur vehicle for this launch.

In the Upper Stage budget, requirements for the IUS include the final Shuttle launch of the TDRS-F into geosynchronous orbit in 1995. The AXAF-I launch in 1998 would require an upper stage if it is launched on the Shuttle as now baselined. However, final launch vehicle selection has not yet been made, and NASA is actively pursuing a possible Titan IV/Centaur launch for this program.

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1994 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE COMMUNICATIONS

SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space network	338,875	298,200	230,085	173,900	SF 4-4
Ground networks	283,000	314,600	306,901	315,980	SF 4-12
Communications and data systems	281,400	308,200	299,244	330,620	SF 4-21
Total	903,275	921,000	836,230	820,500	

Distribution of Program Amount by Installation

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
Ames Research Center	13,000	16,100	15,663	17,700
Goddard Space Flight Center	581,823	607,800	532,521	516,780
Headquarters	73,491	46,500	42,046	40,400
Jet Propulsion Laboratory	177,739	186,100	187,400	185,800
Johnson Space Center	21	--	200	--
Kennedy Space Center	700	--	--	--
Langley Research Center	1	--	--	--
Lewis Research Center	200	200	200	200
Marshall Space Flight Center	56,300	64,300	58,200	59,620
Total	903,275	921,000	836,230	820,500

OBJECTIVES AND JUSTIFICATION

The purpose of this program is to provide the vital tracking, telemetry, command, data acquisition, communications, and data processing required by all NASA flight projects. Some of these capabilities are provided on a reimbursable, noninterference basis to projects of other Government agencies, commercial firms, and international organizations.

These capabilities are provided to meet the requirements of NASA's Earth orbital, planetary, and solar system exploration spacecraft missions, research aircraft, and sounding rockets and balloons. Included in Earth orbital activities are the Space Transportation System (STS), Spacelabs, and scientific and applications missions. The various capabilities provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of science and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) reception of television transmissions from space vehicles; (e) transmissions of commands from ground facilities to the spacecraft; (f) voice communications with astronauts; (g) transfer of information between the various ground facilities and control centers; and (h) processing of data acquired from the launch vehicles and spacecraft. These capabilities are essential for operating and maintaining U.S. space assets to achieve the scientific objectives of all flight missions and for executing the critical decisions necessary to the success of these missions.

NASA has three separate tracking networks to meet the requirements of NASA flight missions. These are: the Spaceflight Tracking and Data Network (STDN), for launch vehicles including STS launch and landing operations; the Deep Space Network (DSN), for planetary and interplanetary flight missions, high Earth-orbital missions, and low Earth-orbital missions that are unable to communicate through the Space Network; and the Space Network, which includes the Tracking and Data Relay Satellite System (TDRSS), required by most low Earth-orbital missions. The Space Network and STDN are managed by the Goddard Space Flight Center (GSFC). The DSN is managed by the Jet Propulsion Laboratory (JPL).

NASA has two communications networks: NASA Communications (NASCOM), which is managed by the GSFC, and the Program Support Communications Network (PSCN), which is managed by the Marshall Space Flight Center (MSFC). The NASCOM interconnects the tracking networks with the spacecraft control centers and data processing facilities associated with each mission. This network provides three classes of service: a relatively low data rate system for the launch and landing facilities at the Kennedy Space Center (KSC) and the Dryden

Flight Research Facility (DFRF); a medium rate system for the DSN; and a high rate system for the Space Network. The PSCN provides computer networking, voice and video conferencing, facsimile and electronic mail to all NASA programs and projects. The PSCN network interconnects all NASA locations and selected contractor sites via wideband terrestrial and satellite facilities.

Highly specialized computation facilities provide real-time information for mission control and data processing of the scientific, applications, and engineering data which flow from flight projects. In addition, instrumentation facilities are utilized for sounding rocket and balloon launchings and flight testing of aeronautical research aircraft.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The current estimate of $836.2 million for FY 1993 is $84.8 million below the budget request and is consistent with Congressional action. This funding level includes an increase of $5.2 million due to the redistribution of the Research Operations Support (ROS) account offset by the directed reduction of $65.0 million for TDRS II, and a general reduction of $25.0 million. This general reduction is accommodated within the Space Network (-$4.9 million), Ground Networks (-$8.3 million), and Communications and Data Systems (-$11.8 million).

Within the Space Network, the FY 1993 budget reflects increased funding requirements of $28.6 million for the Second TDRSS Ground Terminal, $6.1 million for Systems Engineering, and an increase of $1.8 million transferred from the ROS account. This is offset by reduced funding requirements of $14.0 million for the basic TDRS system and operations, reducing Replacement Spacecraft by $10.8 million and deleting $9.9 million associated with the suspended procurement of TDRS II replenishment spacecraft. As directed by Congress, $15 million is being made available to upgrade the existing Network Control Center.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget reflects an increasing level of flight programs plus the development and implementation activities to meet future mission requirements. A significant portion of the budget is driven by the requirements of operational spacecraft. Among these spacecraft are: Galileo; Mars Observer; Hubble Space Telescope (HST); Ulysses; the Compton Gamma Ray Observatory; Cosmic Background Explorer, (COBE); the Upper Atmosphere Research Satellite (UARS); Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX); Extreme Ultraviolet Explorer (EUVE); Ocean Topography Experiment (TOPEX); Pioneer spacecraft; Voyager spacecraft; and the Shuttle missions. Funds are also required in FY 1994 to support approved missions currently under development. During FY 1994, the F-7 replacement TDRS spacecraft, which is planned for launch in FY 1995, will undergo integration and test; the Second TDRSS Ground Terminal (STGT) will initiate operations; and contract award for TDRS replenishment spacecraft will occur.

BASIS OF FY 1994 FUNDING REQUIREMENT

SPACE NETWORK

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system (TDRSS)	63,406	46,200	32,116	23,300
Space network operations	40,968	61,900	58,163	36,700
Systems engineering and support	44,001	59,900	66,706	32,500
TDRS replacement spacecraft	43,568	10,800	--	5,700
Second TDRSS ground terminal	140,100	44,500	73,100	27,700
TDRS II spacecraft	6,832	74,900	--	--
TDRS replenishment spacecraft	--	--	--	48,000
Total	338,875	298,200	230,085	173,900

OBJECTIVES AND STATUS

The Space Network consists of the Tracking and Data Relay Satellites (TDRS) and the associated ground elements necessary to meet the communications requirements of Earth orbital spacecraft missions. The current TDRS constellation consists of two fully functional satellites, and two partially functional satellites. Another satellite, launched in January 1993, will serve as a fully functional spare. One partially functional satellite is being operated to reduce schedule overloads during Shuttle missions, and the other will be repositioned to increase data return from the Compton Gamma Ray Observatory, which has recorder problems. The ground facilities are located in White Sands, New Mexico. Satellite and ground communication links interconnect the White Sands facilities with the Network Control Center (NCC) at the Goddard Space Flight Center (GSFC) and other spacecraft mission facilities.

The increased funding required by the Second TDRSS Ground Terminal (STGT) has been accommodated by realigning other program funds.

The FY 1994 request includes funding for: maintenance and operations of the White Sands complex and the NCC; systems engineering and mission planning; equipment modification and replacement; continued development of the replacement spacecraft; the continued development of the second ground terminal and modernization of the first ground terminal at White Sands; and initiation of the TDRS replenishment spacecraft program.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system (TDRSS)	30,731	46,200	32,116	23,300
Federal finance bank payment...........	32,675	--	--	--
Total...............................	63,406	46,200	32,116	23,300

OBJECTIVES AND STATUS

The TDRSS serves as the communication link between the spacecraft operating in Earth orbit and ground facilities. The TDRS provides space-to-space communications with the orbiting spacecraft and relays data and command to and from the White Sands ground facilities which are interconnected with project control centers and other facilities.

The Space Network has provided data communications to the Shuttle missions, including Spacelabs; and orbiting satellite missions such as the Earth Radiation Budget Satellite (ERBS), the Cosmic Background Explorer (COBE), the Hubble Space Telescope (HST), the Compton Gamma Ray Observatory, Upper Atmosphere Research Satellite (UARS), Extreme Ultraviolet Explorer (EUVE), and Ocean Topography Experiment (TOPEX).

The TDRS-4 and TDRS-5 are fully functional, with one positioned in the west and the other in the east. The TDRS-6 was successfully launched in January 1993 to serve as a central back up. The two partially degraded spacecraft, TDRS-1 and TDRS-3 will be utilized to increase data return from the Compton Gamma Ray Observatory and to reduce schedule overloads during Shuttle missions, respectively.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $14.1 million reflects $14.6 million program savings that were achieved as a result of contract negotiations and crew sharing with the Replacement Spacecraft program; reduced ground operations indirect costs; and an increase of $0.5 million to accommodate the Research Operations Support (ROS) transfer.

BASIS OF FY 1994 ESTIMATE

During FY 1994, operations and maintenance activities will continue at the White Sands complex. The spacecraft portion of the program will have been completed.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Space network operations..............	40,968	61,900	58,163	36,700

OBJECTIVES AND STATUS

The primary objective of Space Network Operations is to provide for the operation and maintenance of the ground systems and facilities required to schedule, control and operate the network system. This network operations system provides the planning, training, staffing, and preparation for upcoming missions necessary to assure the operational network capability required by the space missions in low Earth orbit.

The NASA Ground Terminal (NGT) at White Sands monitors TDRSS performance, provides fault isolation monitoring for the network, and serves as the communications interface with all other facilities. The White Sands Ground Terminal (WSGT) controls and operates the TDRS satellites and relays all telemetry and commands to and from the customer spacecraft.. The STGT at White Sands will be fully staffed and prepared for the initiation of operations in the first quarter of CY 1994. This new facility will operate in parallel with the WSGT for a period, and then assume the operational role while WSGT is undergoing modernization. The NCC at GSFC manages and schedules TDRSS services for all customer spacecraft.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $3.7 million includes an increase of $0.6 million transferred from the ROS account and a decrease of $4.3 million in program adjustments that are being made to accommodate a portion of the reductions specified by Congress. This was accomplished by reductions in training, documentation, NGT operations, and various other activities.

BASIS OF FY 1994 ESTIMATE

The requested funding provides for the operation of Space Network facilities 24 hours per day, seven days per week, and for related hardware and software maintenance. Funding is also provided for a variety of activities such as operational analysis, mission planning, simulations, compatibility testing, and documentation for missions requiring Space Network capabilities.

All responsibilities for Flight Dynamics Facility (FDF) operations, including orbit determination, mission acquisition, and position determination will be consolidated within the Communications and Data Systems program beginning in FY 1994. This transfer of responsibility will streamline overall management of the FDF.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Systems engineering and support........	44,001	59,900	66,706	32,500

OBJECTIVES AND STATUS

The objective of Systems Engineering and Support is to provide the engineering services, hardware, and software development required to sustain and modify the Space Network elements. Systems engineering is supplied primarily through support service contracts. These contracts provide for equipment design and replacement, logistics, and specialized maintenance and operations activities including configuration management and procedure development. Ongoing activities include network integration and test, systems reliability analyses, test equipment procurement, and software modifications required for reliable operations.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase of $6.8 million reflects the addition of $9.9 million to develop implementation systems for improved Compton Gamma Ray Observatory data retrieval; an increase of $0.7 million transferred from the ROS account; and a decrease of $3.8 million in cancellation and reductions to studies and long range planning and analytical engineering efforts.

The majority of the directed funding for NCC improvement is provided by this budget element.

BASIS OF FY 1994 ESTIMATE

Funds are requested to provide systems engineering, hardware and software maintenance, sustaining engineering, test equipment, and vendor services for specialized equipment and Space Network subsystems. Funding includes NCC hardware replacement and the software modifications required to interface with the STGT.

Consistent with the decision to consolidate all responsibilities for FDF management within the Communications and Data Systems program, all FDF sustaining activities previously budgeted within Systems Engineering and Support will be transferred beginning in FY 1994.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
TDRS replacement spacecraft (F-7)......	43,568	10,800		5,700

OBJECTIVES AND STATUS

The objective of this program is to provide the TDRS-7 spacecraft, which is required to maintain the TDRS constellation. This spacecraft is functionally identical to the previous six satellites. Design changes have been made to improve reliability and to accommodate subsystems and parts that are no longer being produced. Final hardware deliveries will occur in FY 1993, and integration and test activities will resume. A second source has been secured for solid-state power amplifiers, solving long standing technical problems.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $10.8 million is due to the restructuring of the integration and test phase of TDRS-7 to a later period. The restructuring reflects sharing of the crew with the TDRSS program during the TDRS-6 launch activities. FY 1993 activities will be carried out with prior year funding planned for the earlier integration and test schedule.

BASIS OF FY 1994 ESTIMATE

The requested funds will continue spacecraft and payload integration and test activities in FY 1994. Thermal vacuum spacecraft testing will be completed, integration systems test completed, and final assembly initiated. TDRS-7 is planned for launch in FY 1995 on the Shuttle.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Second TDRSS ground terminal (STGT)....	140,100	44,500	73,100	27,700

OBJECTIVES AND STATUS

The objectives of the STGT program are: to eliminate the Space Network's critical single point of failure at the existing ground terminal at White Sands, New Mexico; to upgrade the existing ground terminal for more

reliable and more cost-effective operations; to provide additional capability that allows continued use of partially failed spacecraft; and to provide the capability of performing ground terminal maintenance and modifications on the existing terminal without interruption to Space Network operations.

The hardware chassis fabrication is complete for all six Space-to-Ground Link Terminals (SGLT) and the subsystem testing to validate the hardware and software functionality continues. Systems level testing conducted at the STGT site was initiated in parallel with subsystem tests. Most of the STGT equipment has been delivered to the site and is undergoing test and all the required cable has been installed. The pace of activity there will continue to increase as hardware installation, procedure development, and other preparations for the initiation of final acceptance testing continue. System level testing is scheduled to be completed by the end of FY 1993.

CHANGES FROM FY 1993 ESTIMATE

The increase of $28.6 million is to accommodate the cost growth incurred during FY 1993. The cost increase was driven by lack of engineering model hardware, underestimates of the complexity of hardware and software development, and subcontractor technical problems. Details on the cost growth are available in the Special Report on STGT provided to the House and Senate Committee on Appropriations on September 18, 1992. Initial operations capability for the STGT is now scheduled for the end of January 1994.

BASIS OF FY 1994 ESTIMATE

The funding requested will provide for network level testing and preparations for initial operations scheduled for January. As operational readiness is validated by STGT parallel operations with the White Sands Ground Terminal (WSGT), the integration and test of the remaining three SGLTs for the WSGT upgrade will be concluded. When the STGT assumes the operational load near the end of the fiscal year, the WSGT will be shut down, the old equipment removed, and the facility remodeled for the installation of the remaining three SGLTs.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite (TDRS) II	6,832	74,900	--	--

OBJECTIVES AND STATUS

The objective of the program is to design, develop, and competitively procure improved relay satellites required for continuity of Space Network operations through the next decade. TDRS II includes a Ka-band single access service that operates-in a new protected frequency band to reduce the possibility of harmful interference. This frequency will also make TDRS compatible with future international systems (Japan and Europe). TDRS II includes an enhanced multiple access capability which utilizes existing phased array technology to increase antenna gain; this will permit off loading customers from scarce single access antennas, thereby reducing the number of TDRS II satellites required. Ground system modifications to accommodate these new services are included in the procurement.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $74.9 million is in response to a directed Congressional reduction and subsequent cancellation of the TDRS II procurement. The TDRS II procurement of six spacecraft was first suspended to assess alternatives, including an unsuccessful effort to procure a single spacecraft of the existing design. A search for more affordable alternatives led to canceling TDRS II and initiating procurement of spacecraft functionally equivalent to the existing design as an interim solution to NASA's pressing needs.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay replenishment spacecraft	--	--	--	48,000

OBJECTIVES AND STATUS

The Tracking and Data Relay Satellite System program has been very successful over its ten year history. While increasing NASA's global coverage from 15 to 85 percent and the data rates by a factor of six, 15 ground stations have been closed and operating costs reduced. The objective of the replenishment program is to ensure continuation of this essential capacity into the next century.

By the end of the decade many of the initial TDRS satellites will have exceeded their expected lifetime. Analyses indicate that without additional spacecraft, a substantial part of NASA's communications requirements for operating current and approved new missions cannot be met in the latter part of this decade. Present programs such as the Space Transportation System (STS), HST, Compton Gamma Ray Observatory, TOPEX plus approved future NASA missions preparing for launch--a dozen missions representing a major investment --cannot accomplish their objectives without a reliable Space Network. The risks to these programs must be balanced by a continuing capital investment in replenishment spacecraft.

Since three spacecraft are needed in close succession, all will be incorporated in this interim procurement. The early funding profile will not be increased significantly for a multiple spacecraft buy. More importantly, total runout costs will be substantially reduced compared with individual buys. The total costs will be lower due to a common design, assembly, and test procedures, and parts buys. Also lower costs will result from the increased competition of a multiple buy.

A development contract will be competitively awarded in mid-1994. This contract will be fixed price to ensure cost containment. The fixed price approach is made possible with the spacecraft specification based on the functional equivalent of the original TDRS service. (Identical spacecraft of the previous design will be acceptable.) A higher performance phased array antenna will be considered if it is cost effective. Any associated ground systems modifications will be included in the scope and costs, and life-cycle cost evaluations will be a part of the selection process. Although launch services will be separately funded and government provided, selection will consider overall cost to the government.

BASIS OF FY 1994 ESTIMATE

The requested funding will provide for a development contract award in mid-1994. The first replenishment spacecraft is expected to be available for launch in mid-1998.

BASIS OF FY 1994 FUNDING REQUIREMENT

GROUND NETWORKS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network systems implementation	3,100	5,500	5,526	6,100
Spaceflight tracking and data network operations	56,040	64,500	61,596	60,700
Deep space network systems implementation	79,560	82,600	80,301	89,900
Deep space network operations..........	106,750	119,000	118,000	112,100
Aeronautics, balloons, and sounding rocket systems implementation	15,700	17,600	17,591	20,500
Aeronautics, balloons, and sounding rocket operations	21,850	25,400	23,887	26,680
Total............................	283,000	314,600	306,901	315,980

OBJECTIVES AND STATUS

Three broad categories of missions depend on the Ground Networks: (1) Earth orbital; (2) planetary and solar system exploration; and (3) aeronautics, balloons, and sounding rockets. The Deep Space Network (DSN) is required for the planetary and solar system exploration missions as well as Earth orbital missions not compatible with the Tracking and Data Relay Satellite System (TDRSS) Space Network. Aeronautical, balloon and sounding rocket research requires specially instrumented ranges as well as mobile stations. The Spaceflight Tracking and Data Network (STDN) stations at Merritt Island, Florida, Bermuda, and Dakar, Senegal, are required during the launch phase of Space Transportation System (STS) missions. Both the DSN and STDN stations also provide emergency coverage of Earth-orbiting spacecraft if they become unable to communicate through the TDRSS Space Network. Range safety functions are provided via Bermuda and Wallops. The requirements of Space Transportation Systems (STS) landings at the Dryden Flight Research Facility (DFRF) are met by the Western Aeronautical Test Range (WATR) at DFRF and the DSN facilities at Goldstone. The Wallops Flight Facility (WFF) is used for tracking orbital scientific spacecraft, STS, Expendable Launch Vehicles (ELV's), and routine aeronautic, balloon, and sounding rocket activities.

The Ground Networks program funding provides the operation and maintenance of the worldwide tracking facilities. Implementation funds are used for the design, development, and implementation of hardware and software to service NASA flight mission operations.

The workload in FY 1994 will include the STS, ELV's, Mars Observer, Galileo, Total Ozone Mapping Spectrometer (TOMS), Ulysses, International Solar Terrestrial Physics (ISTP), High Resolution Microwave Survey (HRMS), Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX), Fast Auroral Snapshot Explorer (FAST), Pioneers-10 and -11, International Cometary Explorer (ICE), and the Voyager-1 and -2 in addition to aeronautic, balloon, and sounding rocket missions. Preparations are under way for missions such as Cassini, future Small Explorer (SMEX) and cooperative missions, such as the Advanced Earth Observing Satellite (ADEOS) Japanese mission, and the cooperative Synthetic Aperture Radar Satellite (RADARSAT) mission with Canada. Work is in progress to prepare for two Radio Astronomy cooperative missions -- the Russian Radioastron project, and the Japanese Orbiting Very Long Baseline Interferometry Project (VSOP).

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) systems implementation	3,100	5,500	5,526	6,100

OBJECTIVES AND STATUS

The STDN systems implementation program encompasses the procurement of hardware and engineering services to sustain, modify, and replace existing ground network capabilities to ensure reliable tracking, command and data acquisition required by NASA's STS missions.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase in FY 1993 funding is due to the transfer of funds from the Research Operations Support (ROS) account.

BASIS OF FY 1994 ESTIMATE

The FY 1994 request provides funds to upgrade equipment and subsystems required for the STS operations at the Merritt Island, Florida, and Bermuda STDN tracking stations. Funding is also provided for the replacement of obsolete, difficult-to-maintain equipment. Specific FY 1994 projects include replacement of obsolete antenna control consoles and radar rehabilitation.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network (STDN) operations	56,040	64,500	61,596	60,700

OBJECTIVES AND STATUS

The primary function of the STDN is to provide prelaunch, launch, and landing communications required by the STS. In addition, this network provides emergency communications to orbiting spacecraft in the event that they are unable to communicate through the TDRSS/Space Network. The network also meets similar requirements of other U.S. government agencies, private industry, and international organizations on a reimbursable basis.

The STDN consists of three ground stations located at Bermuda; Merritt Island, Florida; and Dakar, Senegal. Each station is capable of tracking spacecraft, transmitting commands for spacecraft and experiment control, and receiving engineering and scientific data from the spacecraft. They also provide primary and backup voice communications for STS operations and range safety functions for the Eastern Range.

The STDN logistics program includes a supply depot, a magnetic tape acquisition and certification facility, and centralized equipment repair and shipping facility. The depot is operated as a centralized facility and services the Communications and Data Systems program; the Deep Space Network; the Space Network; the Aeronautics, Balloons, and Sounding Rocket program; and the STDN. It is managed by the Goddard Space Flight Center (GSFC).

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $2.9 million includes a decrease of $3.0 million being made to accommodate a portion of the general reduction specified by Congress that will be achieved by a drawdown of spare parts from the logistics depot, and an increase of $0.1 million resulting from the transfer of ROS funds.

BASIS OF FY 1994 ESTIMATE

The FY 1994 request provides for the operation and maintenance of the three ground stations, centralized logistics operations, and limited tracking purchased from the Department of Defense (DOD) and the University of Chile.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Deep space network (DSN) systems implementation	79,560	82,600	80,301	89,900

OBJECTIVES AND STATUS

The primary role of the DSN is to provide communication between interplanetary spacecraft and the Earth. The DSN receives science and engineering telemetry, and transmits command, control and navigation signals to a variety of spacecraft at distances as great as 8 billion kilometers from Earth. The major objectives of the DSN are: (1) to communicate with scientific spacecraft at ever greater distances and to increase the ability to receive data from the far reaches of the solar system; (2) to communicate with Earth-orbiting spacecraft that are non-TDRSS compatible; (3) to provide navigation for precision spacecraft targeting and probe delivery; and (4) to provide the capacity and capability to service future NASA missions.

The systems and facilities required by spacecraft at the limits of the solar system are highly specialized and include large aperture antennas, which can receive extremely weak radio signals. These antennas use ultra-sensitive receivers and powerful transmitters. Extremely stable time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the Network Operations Control Center located at the Jet Propulsion Laboratory (JPL) and the Deep Space Communications Complexes located in California, Spain, and Australia. An orderly, phased upgrade program has been established to increase DSN capacity and incorporate new required capabilities for current and future missions. These improvements are needed to accommodate the increasing number and sophistication of spacecraft. Specific improvements include additional antenna subnetworks, which can be arrayed together (combined electronically) to effectively improve performance and implementation of systems for two cooperative Orbiting Very Long Baseline Interferometry (OVLBI) Astronomy mission, VSOP and Radioastron; Cassini; Galileo; the High Resolution Microwave Survey (HRMS); and two joint Earth observation missions, RADARSAT and ADEOS.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $2.3 million reflects program adjustments that are being made by deferring and delaying various activities to accommodate a portion of the general reduction specified by Congress.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget includes funding for activities necessary to assure the availability of alternate mission capabilities for Galileo. It also provides for a new DSN 11-meter antenna subnet and completion of modification to the Green Bank Radio Observatory's 14-meter antenna for use in the OVLBI cooperative missions with NASA's Russian and Japanese partners. The FY 1994 budget funds sustaining activities for DSN reliability and maintainability. This budget provides funding for multimission improvements needed to accommodate a variety of missions that will be operating in the mid-to-late 1990's including Cassini, International Solar Terrestrial Physics, and Mars Observer.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Deep space network operations..........	106,750	119,000	118,000	112,100

OBJECTIVES AND STATUS

The three DSN complex locations (Goldstone, California; Canberra, Australia; and Madrid, Spain) are approximately 120 degrees apart in longitude to permit continuous viewing of planetary spacecraft. Each complex has four antennas -- one 70-meter, two 34-meter, and one 26-meter. The 26-meter antennas are required by some Earth-orbiting spacecraft, such as Nimbus-7, Solar-A, and Solar Anomalous, and Magnetospheric Particle Explorer (SAMPEX), and for spacecraft emergencies. The complexes are staffed for around-the-clock operations. A central network control center is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. Other DSN facilities include a spacecraft compatibility test area at JPL and a launch operations and compatibility facility at the Merritt Island Spaceflight Tracking and Data Network (STDN) site.

Since 1989, four interplanetary spacecraft, which require telecommunications with the DSN, have been launched -- Magellan, Galileo, Ulysses, and Mars Observer. Magellan began mapping the planet Venus in 1990, and mapped more than 99 percent of that planet before initiating studies of the gravity field. Galileo recently flew within 190 miles of the Earth on its final planetary assist as the spacecraft begins the initial phase of its journey to Jupiter. Later this year Galileo will fly near the asteroid Ida.

Ulysses flew past Jupiter in February 1992, where it received a gravity assist to deflect it on a trajectory to the Sun's polar regions. In September 1992, Mars Observer was launched and will arrive at Mars in August 1993. The DSN also provides communications for the Voyagers, the Pioneers, International Cometary Explorer (ICE), and the International Solar Terrestrial Physics (ISTP)/Geotail spacecraft.

In response to the increasing telecommunications requirements, the capacity of the DSN will be increased through the phased implementation of additional antennas throughout the next decade. The antennas are funded within the Construction of Facilities budget.

The DSN facilities are also used for ground-based solar system radar and radio astronomy observations. The network's ultra-sensitive antennas are being used in an attempt to learn more about pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena. The solar system radar is useful in understanding surface characteristics of planets, asteroids, comets, moons, near-Earth asteroids, and ring systems. Radar observations were taken of the asteroid Toutatis late last year as it passed within 2.5 million miles of Earth.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $1.0 million reflects program adjustments that are being made to accommodate a portion of the general reduction specified by Congress.

BASIS OF FY 1994 ESTIMATE

The DSN operations funding provides for the maintenance and operation of network facilities and the engineering required for continuing operation of the network. The expected DSN workload in FY 1994 includes Galileo, Ulysses, Mars Observer, Pioneer-10 and -11, Voyager-1 and -2, ICE, Nimbus-7, Solar-A, Geotail, Wind, Astro-D, Total Ozone Mapping Spectrometer (TOMS), SAMPEX, and STS. The DSN will also provide communications for spacecraft emergencies and serve as backup to the TDRSS Space Network. Major TDRSS users that have used ground-based emergency communications include STS, Hubble Space Telescope (HST), Compton Gamma Ray Observatory, Cosmic Background Explorer (COBE), Upper Atmospheric Research Satellite (UARS) and TOPEX.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons and sounding rocket (AB&SR) systems implementation	15,700	17,600	17,591	20,500

OBJECTIVES AND STATUS

The Aeronautics, Balloons, and Sounding Rocket (AB&SR) systems implementation program is directed primarily at the replacement of obsolete systems and the upgrade of facilities to assure reliable service to NASA's research programs.

The tracking and data acquisition facilities receive the scientific and engineering data from research aircraft, balloons, sounding rockets and some Earth-orbiting spacecraft engaged in scientific research. The primary fixed facilities are located at the WFF, the Ames Research Center (ARC), and the DFRF.

The WFF, a part of the GSFC, operates a range at Wallops Island, Virginia, conducts aeronautics research, sounding rocket and small meteorological balloon launches, and tracks Earth-orbiting satellites. The WFF also manages the operation of off-site ranges located at the White Sands Missile Range, New Mexico; Poker Flat Research Range, Alaska; and the National Scientific Balloon Facility, at Palestine, Texas, and Ft. Sumner, New Mexico. In cooperation with the National Science Foundation (NSF), a transportable facility will be provided at McMurdo Sound, Antarctica, to meet the requirements of the joint US/Canadian RADARSAT mission. Mobile campaigns for balloon and sounding rocket launches are conducted at various sites, as required, throughout the world. The funding in this budget is used to provide tracking and data acquisition for these activities.

The ranges at Moffett Field, Crows Landing and the DFRF are under the management of ARC and are configured for aeronautics research. The DFRF has the additional responsibility of providing tracking for STS landings.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The FY 1993 reduction reflects a decrease made to accommodate a portion of the general reduction specified by Congress, mostly offset by an increase due to the transfer of funds from the ROS account.

BASIS OF FY 1994 ESTIMATE

The aeronautical research efforts and scientific experiments using sounding rockets and balloons require fixed and mobile instrumentation systems. These include radar, telemetry, optical, communications, command, data handling and processing systems. The FY 1994 budget request includes funds to maintain these facilities, to replace test and calibration equipment, and refurbish or modify equipment to assure reliable performance. Funds are also included for acquisition of new mobile tracking systems for NASA's Small Explorer program, RADARSAT, and for the automation of the Wallops Orbiting Tracking Station.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons, and sounding rocket (AB&SR) operations	21,850	25,400	23,887	26,680

OBJECTIVES AND STATUS

The operations element of the AB&SR program includes the operations and maintenance of ground-based tracking instrumentation systems, both fixed and mobile, under the management of the ARC and the GSFC. These facilities are employed for NASA aeronautics, sub-orbital, and a limited number of Earth-orbiting research programs. Funding provides for services required to operate and maintain the tracking radar, telemetry, data acquisition, data processing, data display, communications and special purpose optical equipment essential for these research programs.

The Western Aeronautical Test Range (WATR), composed of DFRF, Moffett, and Crows Landing facilities, maintains an aggressive schedule of aeronautics research operations. During FY 1992, 1,104 missions were conducted at DFRF and Moffett. The trend continues upward in FY 1993 with approximately 1,216 aeronautical missions planned. Programs tracked from these ranges included high performance aircraft, advanced technology research aircraft, and complex control systems and powered lift technologies. STS tracking and telemetry for landing operations are coordinated through DFRF.

The WFF provides tracking, telemetry, and command functions for NASA's aeronautics, sounding rocket, balloon, and some Earth-orbiting satellite programs. During FY 1992, 304 aeronautics missions were conducted. These were related to such programs as automatic landing operations using Global Positioning Satellite inputs, aircraft performance using vortex flap technology, the Pacific Joint Ocean Flux Study, the Greenland Ice Cap Measuring Program, the Shuttle Microwave Scanning Beam landing system checkout, the Puerto Rican El Coqui Sounding Rocket Campaign, WFF Range Surveillance, and runway friction testing. Approximately the same number of aeronautics missions will be conducted in FY 1993.

In FY 1992, WFF supported 76 sounding rocket missions from WFF and several worldwide sites which covered a variety of NASA and DOD science disciplines. Approximately 75 are planned for FY 1993. WFF is also the center for NASA Scientific Balloon operations and launched a total of 154 science research balloons in FY 1992, with approximately 100 planned for FY 1993.

In FY 1992, a new Integrated Range Control Center was completed and placed in operation at WFF. This facility combines both rocket launch and aeronautical test control centers into a single facility with the range computer complex.

A new 8-meter precision tracking telemetry antenna was placed in operation at the Poker Flat Research Range in Alaska for support of the NASA Plasma Physics Program.

A new precision tracking mobile C-Band radar passed final acceptance tests and was placed in operation.

In FY 1993, the Wallops Orbital Tracking Station will provide 24-hour space tracking operations for missions such as Cosmic Background Explorer (COBE), International Ultraviolet Explorer (IUE), Interplanetary Monitoring Platform-8 (IMP), Nimbus-7, Meteosat, NOAA-10, TOMS/Meteor-3, Roentgen Satellite (ROSAT) and SAMPEX.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $1.5 million reflects an increase of $0.4 million being made as a result of transferring funds from the ROS account along with $1.9 million in program adjustments that are being made to accommodate a portion of the general reduction specified by Congress. This will require operations, engineering, and logistics reductions at WFF, as well as reductions in spares and test equipment at WATR.

BASIS OF FY 1994 ESTIMATE

The funding for the AB&SR Operations program includes contractor operations and maintenance personnel and technical services used to provide tracking, data acquisition, command and control for the ground-based fixed and mobile instrumentation systems for the ongoing sounding rocket, balloon, certain Earth-orbiting satellites, and aeronautical research programs. Funds are included necessary to prepare for Antarctic operations to meet Radarsat requirements, and for the operation and maintenance of the receiving ground station of the Alaska SAR Facility. Funds are also provided for aeronautics research operations and radar overhauls at the WFF and the DFRF.

BASIS OF FY 1994 FUNDING REQUIREMENT

COMMUNICATIONS AND DATA SYSTEMS

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation..	10,300	8,700	8,769	14,600
Communications operations..............	122,640	131,200	128,054	124,520
Mission facilities.....................	14,000	17,100	14,241	18,500
Mission operations.....................	48,400	52,500	50,336	52,700
Data processing systems implementation.	24,360	30,000	30,670	33,600
Data processing operations.............	61,700	68,700	67,174	86,700
Total...........................	281,400	308,200	299,244	330,620

OBJECTIVES AND STATUS

The Communications and Data Systems program provides for the development and operation of facilities and systems that are required for data transmission, mission control and data processing for space flight missions. The demand for these services are increasing sharply as new flight missions are added to the continuing operations of older spacecraft. FY 1992 began with the continued operation of nine spacecraft: Upper Atmosphere Research Satellite (UARS), Compton Gamma Ray Observatory, Cosmic Background Explorer (COBE), Earth Radiation Budget Satellite (ERBS), Hubble Space Telescope (HST), International Cometary Explorer (ICE), Interplanetary Monitoring Platform-8 (IMP), International Ultraviolet Explorer (IUE), and NIMBUS. During the past year, two major explorers were launched: the Extreme Ultraviolet Explorer (EUVE) and the Solar Anomalous and Magnetosphere Particle Explorer (SAMPEX). Each explorer has corresponding spacecraft control and data processing facilities that were completed and placed into operation. The addition of the EUVE and SAMPEX explorers to NASA's operational fleet has resulted in an increase of approximately 40 percent in the quantity of scientific data processed on a continuous basis by the Office of Space Communications.

Communications circuits and services provide for the transmission of data between and among the remote tracking stations, the Tracking and Data Relay Satellite System (TDRSS) Ground Terminal, launch areas, the mission control centers, and data processing facilities. Real-time information is crucial to determine the condition of the spacecraft and payloads, responding to failures or dangerous situations, and for the generation of spacecraft and payload control commands. Data received from the various spacecraft must be transformed into a form usable for spacecraft monitoring in the control centers, and for analysis by the scientific investigation team.

In addition to operating spacecraft, preparations are under way for several new missions to be launched including Wind, Polar, Solar and Heliospheric Observatory (SOHO), Cluster, Fast Auroral Snapshot Explorer (FAST), Submillimeter Wave Astronomy Satellite (SWAS), X-ray Timing Explorer (XTE), Advanced Composition Explorer (ACE), Total Ozone Mapping Spectrometer-1 (TOMS-1), Earth Observing Satellite (EOS) AM-1, and the Tropical Rainfall Measurement Mission (TRMM). The Space Shuttle will carry several Spacelab and attached payloads into orbit this year, and data processing preparations are nearing completion for these missions.

To meet the increasing requirements in terms of both quantity of spacecraft being operated and the much larger volumes of data being produced by the newer spacecraft, it is necessary to modernize facilities to expand system capacity and replace aging equipment that is becoming increasingly costly to maintain. The application of advanced technologies such as high-speed Very Large Scale Integration (VLSI) and distributed systems using the new powerful microcomputers has been incorporated into our new facilities, e.g., Transportable Payload Operations Control Center (TPOCC) for SAMPEX and upcoming level zero processor (LZP) for FAST.

In the communications area, planning is continuing for the transfer of many of the domestic (intra-U.S.) transmission services of NASA's global communications network (NASCOM) for operational missions onto the FTS-2000 network. Because of the critical nature of NASCOM, special arrangements are being made with the General Services Administration (GSA) to provide the reliability and diversity requirements that the current NASCOM provides. When these arrangements are completed, circuit transfers will begin and will continue through FY 1993 and FY 1994. The transfer of services to FTS-2000 include those services that are less than 1.5 million bits per second (M b/s). The high speed data services (greater than 1.5 M b/s) and overseas services are beyond the scope of FTS-2000.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation...	10,300	8,700	8,769	14,600

OBJECTIVES AND STATUS

The objective of the Communications Systems Implementation program is to provide the necessary capability in NASCOM to meet new flight program requirements, to increase the efficiency of the network, and to maintain a high level of reliability and security for the transmission of data and commands between U.S. assets in space and their respective control centers.

Major systems implementation projects expected to be completed in FY 1993 that were initiated in prior years include: (1) the upgrade of the data handling capability of the Deep Space Network (DSN) to 1.2 M b/s; (2) operational status of a fiber optic system connecting the two TDRSS ground terminals at the White Sands complex; and (3) the implementation of a new backbone multiplexer/demultiplexer (MDM) system between the White Sands complex, the Goddard Space Flight Center (GSFC), and the Johnson Space Center (JSC).

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase in FY 1993 reflects the transfer of funds from the Research Operations Support (ROS) account.

BASIS OF FY 1994 ESTIMATE

The FY 1994 funding will provide the necessary equipment acquisitions and sustaining engineering modifications required for completion of projects begun in earlier fiscal years. Of particular note are the completion of the digital voice system at GSFC; the acquisition of a new digital matrix switch at the GSFC for greater circuit handling capability; and the continuing upgrade of the DSN to meet the data requirements of the Wind, Polar, and SOHO missions, which are part of the International Solar Terrestrial Program (ISTP).

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Communications operations.............	122,640	131,200	128,054	124,520

OBJECTIVES AND STATUS

The NASCOM network interconnects the tracking and data acquisition facilities for all flight projects via leased voice, data, video, and wideband circuits. The overseas elements of NASCOM employ a sub-switching center at the Jet Propulsion Laboratory (JPL) to improve diversity, connectivity to multiple overseas destinations, and to achieve optimum utilization of circuit bandwidth. Direct services from Madrid and Australia to the JPL were established in FY 1992 to economically provide the increased bandwidth required by new spacecraft under development.

The NASCOM program includes the Agency's television service, NASA SELECT, which allows the American public to witness all manned spaceflight missions and learn of the important discoveries of the scientific missions such as Magellan. NASA SELECT will continue to be used for educational outreach with a potential audience of most universities and high schools, and will continue its coverage to Hawaii and parts of Alaska in FY 1993.

NASA's Program Support Communications Network (PSCN) interconnects the NASA Centers, Headquarters, major contractors, and university locations for the transfer of programmatic and scientific information. The PSCN services include computer networking, electronic mail, and voice and video teleconferencing. The FTS-2000 is now providing the transmission system that services the PSCN. The Marshall Space Flight Center (MSFC) operates the PSCN and serves as its control center.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $3.1 million reflects an increase of $1.6 million that was transferred from the ROS account along with program reductions to the PSCN that include delaying implementation of new requirements and deferring planned improvements of existing services. Planned augmentations have been deferred until FY 1995.

BASIS OF FY 1994 ESTIMATE

The requested FY 1994 funding for the communications operations program provides for the increased system capacity needed for the upcoming ISTP missions, along with the preparations necessary to continue operations of the newly completed TDRSS ground terminal at the White Sands complex. The PSCN provides for the circuits, facilities, and systems integration for programmatic and institutional communications operations. PSCN services include computer networking, voice and video conferencing, facsimile, and electronic mail. In FY 1994, funds are required for continued operation, maintenance, and systems integration of the PSCN hardware and wideband satellite and terrestrial circuits at all NASA locations and certain contractor sites. Network services are required by all NASA programs and projects.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission facilities....................	14,000	17,100	14,241	18,500

OBJECTIVES AND STATUS

The Mission Facilities program provides the systems and capabilities needed for the command and control of NASA's unmanned scientific satellites. Command and control of the spacecraft and on-board experiments are carried out by the respective Payload Operations Control Centers (POCCs) and their auxiliary facilities used for many spacecraft.

The POCCs are responsible for the receipt, processing, and display of spacecraft engineering data and the generation of commands. Five POCCs currently monitor and control 11 spacecraft. In FY 1992, mission control capabilities were implemented for EUVE, which is the last new spacecraft that will be controlled out of the aging Multi-Satellite Operations Control Center, and for the SAMPEX, which is the first spacecraft to be controlled using the new Transportable Payload Operations Control Center (TPOCC) architecture. Future spacecraft POCCs are being implemented in the TPOCC architecture with distributed workstations to take advantage of the increased processing capability and lower cost. Other related mission systems include a JSC/GSFC Shuttle POCC Interface Facility (SPIF) and a Mission Planning/Command Management System to generate command sequences for transmission by the POCCs to the spacecraft, and the User Planning System (UPS) to schedule spacecraft communications periods through the TDRSS.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $2.9 million reflects program adjustments that are being made by deferring and delaying various activities to accommodate a portion of the general reduction directed by Congress.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget request includes funds for continued implementation of mission control capabilities at GSFC for the Small Explorer (SMEX) missions and replacement equipment for the Hubble Space Telescope (HST) control center, which will operate the HST spacecraft until at least FY 2004. Funds are also needed to procure equipment to implement control center facilities for the upcoming TRMM, SOHO, XTE, ACE, and TOMS missions.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Mission operations....................	48,400	52,500	50,336	52,700

OBJECTIVES AND STATUS

The Mission Operations program provides for the operation of the mission control centers and the related software and services necessary for the monitoring and control of in-orbit spacecraft and prelaunch preparations for new spacecraft.

Control facilities for spacecraft/payload operations have the capability for receiving, processing, and displaying spacecraft engineering data and for generating commands. Commands are generated in response to

emergencies and also preplanned in sequences and transmitted to the spacecraft to carry out the mission objectives. Software is developed for each new spacecraft, made up of approximately 50 percent reused standard software and 50 percent new mission unique software. Each facility is operated 24 hours per day, 7 days per week for mission services. For Shuttle missions with attached payloads operated by GSFC, a specialized system processes and displays Shuttle-unique data that is needed for payload control.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $2.2 million includes an increase of $0.3 million associated with the ROS account transfer along with a decrease of $2.5 million which results from a rephasing of the TRMM mission control software and deferral of institutional software systems.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget request includes funds to operate the control centers and facilities for control of 12 operational missions; to complete development of capabilities for three new missions to be launched in FY 1994; and to develop the control center capabilities needed for spacecraft under construction that will be launched beyond 1994. The funds will also be used for development of improvements to the planning, scheduling, and command generation system for the HST, a system to offload recording and analyses functions from the overloaded controlling computers, and to provide a system to schedule the use of the TDRSS when the new second TDRSS ground terminal (STGT) is in place. These enhancements are required to permit the control centers to operate with the evolving NASA ground systems, to control the increased number of spacecraft, and to accommodate the higher data rates and complexity of the new spacecraft.

	1992 Actual	1993 Budget Estimate	1993 Current Estimate	1994 Budget Estimate
		(Thousands of Dollars)		
Data processing systems implementation.	24,360	30,000	30,670	33,600

OBJECTIVES AND STATUS

The Data Processing Systems program provides for the procurement of equipment and development of data processing and computational systems at GSFC that are required by a broad range of Earth orbiting scientific missions. These systems determine spacecraft attitude and orbits, and generate attitude and orbit maneuvers for operating spacecraft. These systems also process the large volume of data produced by the operational spacecraft as a prerequisite to analysis of the data by the individual mission research projects.

Major computational capabilities include the multi-mission Flight Dynamics Facility (FDF), which performs the real-time attitude, orbit, flight maneuver control and ground networks functions. The FDF workload has and will continue to steadily increase as the computational requirements of newly launched spacecraft add to the pre-existing workload of servicing satellites already in orbit. To handle the pending FDF over subscription, a two-phased solution has been put in place. In late 1992, the aged, overloaded FDF computer was replaced with a higher power software compatible computer system. We have also embarked on the migration to a future distributed computing architecture to further increase the capacity and to minimize life cycle cost. Other activities within this program include an engineering capability used to develop and test advanced data system components. Through these facilities, advanced techniques in the areas of remote payload operation and control, expert systems, high-speed data processing, high-level languages, and custom-engineered hardware processors using Very Large Scale Integration (VLSI) will be applied to operational systems to replace costly conventional architectures and reduce operational staffing needs.

In addition, there are four major systems for processing spacecraft data: (1) the Generic Time Division Multiplexer (GTDM) Facility, which processes data from all TDM satellites; (2) the Packet Data Processor (PACOR), which processes data from satellites that employ the new packet technology and protocols; (3) the Hubble Space Telescope Data Capture Facility (HSTDCF), which captures, processes, and forwards the packetized telemetry from the HST to the Science Institute Facility; and (4) the Spacelab Data Processing Facility (SLDPF), which performs the data processing required by Spacelab missions. The final success of the many missions depends on these data systems carrying out their required functions.

The large number of missions using modern packet data systems require corresponding packet data processing services. These missions include the SMEX series, SOHO, Cluster, and others. The existing PACOR capacity must be expanded to provide the required increased data processing capability in a cost-effective way. taking advantage of advances in distributed computing and VLSI digital processing. A laboratory, known as the Advanced On-board System (AOS) testbed, is being developed to evaluate advanced spacecraft data system components and the corresponding ground data handling and processing concepts to determine cost-effective ways to accomplish the high performance requirements of the future.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The increase of $0.7 million includes $0.2 million transferred from the ROS account plus $0.5 million for the HSTDCF software conversion to the extended PACOR system. With the conversion of the HSTDCF software to the multi-mission PACOR system, it will be possible to discontinue the operation of the stand alone HSTDCF, resulting in future cost savings.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget request will provide continued funding for improvements in the existing computation capabilities at GSFC that provide services to NASA spacecraft. The budget request includes funds to develop additional packet data processing capacity needed first by SOHO and also by later missions under development. In addition, the AOS testbed activity is continued. Funds are also requested for upgrading the data processing capabilities at GSFC to facilitate the exchange of data within the data processing complex and to other mission service facilities.

The budget request includes funding for equipment to provide the required reliability and availability of the FDF consistent with commitments to ongoing missions, new mission initiatives, and internal services to the space and ground networks, along with the acquisition of some elements of the future distributed architecture systems. The budget request also includes funding for the Data Systems Technology program to maintain the Very Large Scale Integration (VLSI) capability developed over several years and to apply state-of-the-art technologies to prototype system solutions.

	1992	1993		1994
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Data processing operations............	61,700	68,700	67,174	86,700

OBJECTIVES AND STATUS

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form prior to analysis by the scientific investigation teams. This transformation is performed as part of the data processing function and applies to a wide variety of missions, ranging from the small explorer satellites to more complex imaging satellites.

Telemetry data is the primary product of spacecraft, and the mission objectives are achieved through analysis of this data by the investigators. Within the data processing program, data are processed to separate the information obtained from various scientific experiments aboard the spacecraft, to consolidate information for each experimenter, to determine spacecraft attitude, and to correlate these measurements with time and spacecraft position data.

The management, maintenance, operations, application software development, and software maintenance are performed for the major data processing and flight dynamics facilities. The FDF provides standard attitude products and services for the NASA low Earth-orbital spacecraft in all phases of the mission and orbit and Space Network computation services to a wide range of customers including the Shuttle. Pre-mission analysis is performed to define the flight plans and to specify the Flight Dynamics software that must be developed to monitor and verify the spacecraft attitude control system. The software is developed and operated throughout the life of the missions to ensure the health and safety of the spacecraft.

CHANGES FROM FY 1993 BUDGET ESTIMATE

The decrease of $1.5 million reflects a $0.7 million increase due to the transfer from the ROS account along with $2.2 million of reductions made in operations and maintenance in the Spacelab Data Processing Facility.

BASIS OF FY 1994 ESTIMATE

The FY 1994 budget request provides for operation of the computational and data processing facilities: SLDPF, GTDM, PACOR, HSTDF, FDF, STL, and the AOS testbed. Included in the facilities operation are computer operations and maintenance, rentals and lease of proprietary products, small logistics, management and control of the facility resources, and facility user assistance.

The SLDPF funding provides hardware and software services the to Spacelab and Attached Shuttle Payloads. Pre-mission, mission, and post-mission activities are funded in FY 1994 for the launches of United States Microgracity Payload (USMP) -2, Office of Aeronautics and Space Technology (OAST) -2, Robotic Materials Processing System (ROMPS) -1, International Extreme-UV Far-UV (IEH) -1, and the International Microgravity Laboratory (IML) -2. In addition, preparation for missions to be launched in FY 1995, such as USMP-3, Astro-2, OAST-3, Candidate Materials Space Exposure (CMSE), and IEH-2 are also funded.

The budget request includes ongoing spacecraft services for HST, ICE, ERBS, IMP, IUE, SAMPEX, Compton Gamma Ray Observatory, UARS, Wind, EUVE, and STS Spacelab and other attached payload missions to develop the software enhancements and maintenance necessary to perform spacecraft attitude determination, attitude control and maneuver computations, and data processing. The request also includes new responsibilities for operational support for orbit determination, orbit control and maneuver computations, and network support for manned and unmanned missions.

Pre-mission analysis and planning to produce requirements, specifications, application software, prototyping, and system testing are also funded for the upcoming science and applications missions of Polar, SOHO, XTE, TOMS, FAST, SWAS, TRMM, EOS-AM-1, and ACE.